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ON MUSCULAR MEMORY.

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While a vast amount of minute and laborious study has been given to the investigation of the sensory side of psychical activity, experimental research has as yet accomplished relatively little in the realm of central psychology. This is due partly to the fact that in the order of genetic development the senses come first, and partially also to the increasing difficulty of reducing the more complex mental processes to experimental terms.

Memory, imagination, attention, will, and the affective states furnish but short chapters in the history of experimental psychology in comparison with the numerous and sometimes dreary pages which record the patient and painstaking labor of the psychophysicists. Yet it is to these unfinished chapters that pedagogy looks for the aid which it rightfully seeks from psychology, and it is here that psychology must find its practical justification.

The present research was suggested by an incident in connection with Edith Thomas, a child deaf and blind from her fourth year, and, at the time of the incident, about nine years old. This child was tested by Professor Graham Bell of Washington as to her ability to reproduce by motor imitation the movements of the throat and mouth involved in articulate speech. She succeeded fairly well, pronouncing

the letter K, which offers peculiar difficulty to deaf mutes, with unusual distinctness. When asked to repeat the letter some hours later, she called with an almost perfect enunciation, "Kitty, Kitty, Kitty." Investigation revealed the fact that when at the age of four years the gradual loss of speech had followed that of sight and hearing, the last intelligible word spoken by the child was "Kitty." The reproduction was unconscious, the child having absolutely no idea of what she had done. It was not, then, a reproduction of the word as heard or as associated with something seen, but of a muscular movement, which, latent for five years, was recalled by the suggestion of a similar movement. This incident suggested that possibly, under normal conditions, the muscles play a greater part in our memories than we are accustomed to assign to them.

Every teacher has observed children busily moving their tongue and lips during the memorizing of a lesson, perhaps without thinking that the movement was not a mere habit, but a real aid in the process of memorizing. One case has been reported to me of a teacher who reproved a child for moving his lips, and added, by way of explanation, that it was a bad habit and prevented giving full attention to the lesson. Anyone can find in his own experience familiar examples of memorizing done by the muscles; music, of which not a note can be recalled by sight, and whose auditory image is indistinct, may yet reside in the fingers.

The movements of writing, walking, dancing, and repetition of familiar phrases, all tend to become automatic, that is to say, we dismiss them from the higher cortical centres where consciousness is an accompaniment, to the keeping of the lower centres whose functioning is attended by a minimum of consciousness.

In such cases the motor idea itself sinks below the threshold of consciousness and only the expression remains. As to the dependence of the movement for its reproduction on the motor idea, we have only to recall the difficulty which we experience in attempting to make any muscular movement of which we have no previous experience, and therefore no clear mental image of it, in order to realize that the

mental image of a motion and the actual movement are but two sides of one process. Prof. James' familiar statement that we learn to skate in summer and to swim in winter, is an illustration of this. In this connection also, it is an interesting fact noted by Major Powell that those Indian tribes whose religious rites are connected with dancing, say of the uninitiated, "He does not understand it, because he has not danced it out."

These miscellaneous facts were all suggestive that the influence of the muscular or motor element in memory might be reduced to a laboratory problem and investigated by experimental methods.

The amount of experimental work on Memory already accomplished is very small. Investigations of the effect of repetition and rhythm,[1] the memory span,[2] and some comparisons of the relative value of the disparate senses,[3] chiefly sight and hearing, in memory constitute the principal points toward which research has been directed. The Memory of tones has been investigated by Wolfe.[4] The first psychologist to attempt a definite memory problem was Hermann Ebbinghaus, who undertook and carried out in person a series of experiments little short of heroic.

Out of the eleven vowels and diphthongs and the simple consonants of the German alphabet, he formed twenty-three hundred syllables, each composed of a vowel or diphthong between two consonants. These he mixed together, and, picking them up without prearranged order, formed series of varying lengths. His experiments were chiefly upon the memory span and the effects of repetition. His method of learning the syllables was to read aloud in a monotonous voice series of nonsense syllables of various lengths, regulating the rapidity of reading by the strokes of a metronome, until the series could be just reproduced without error. In case of an error, the series was read through to the end and a fresh beginning made. The number of repetitions neces-

[1] Ebbinghaus, "Ueber das Gednächtniss." Leipzig, 1895.
[2] Jacobs and Bryant, *Mind*, XII, pp. 75 seq.
[3] Münsterberg & Bigham, *Psychological Rev.*, Vol. I, p. 453.
[4] Wolfe, "Ueber das Tongedächtniss."

sary for series of different lengths was recorded, and after certain intervals of time, varying from ten minutes to one or two days, or even longer periods of time, the number of repetitions necessary for relearning the syllable was recorded.

By this means he obtained a standard for measuring the degree of forgetfulness. It was found that the process of forgetting was, at first, slow, and then progressed more rapidly, and finally very slowly again. An hour after the series had first been memorized, the process of forgetting had so far advanced that more than half the time originally employed was necessary for relearning the series. After eight hours had elapsed, two-thirds of the original time was required for relearning, and a month later about four-fifths. These numerical relations Ebbinghaus expresses approximately by the following formula: "The quotients of the amounts retained by the amounts forgotten are to each other inversely as the logarithms of the various periods of time that have elapsed."

In memorizing poetry Ebbinghaus found that the verses of a given poem (Don Juan) can be retained ten times as easily as a series of nonsense syllables of similar length. While this precise statement is questionable, it undoubtedly exemplifies the law that associated ideas are far more easily retained than dissociated ones, as in the case of nonsense syllables.

This research of Ebbinghaus remained the only important experimental work on memory until the work of Müller and Schumann (published in 1893 in the *Zeitschrift für Psychologie*). This work was an investigation of the methods of Ebbinghaus. Ebbinghaus' experiments had all been made upon one subject, himself, and without any special investigation of the effects of rhythm and association upon his series of syllables. Müller and Schumann made these points the subject of minute and careful investigation, their experiments extending over a period of nearly five years. The following very brief summary gives the more important results of their work. In series of syllables taken in the promiscuous order of Ebbinghaus, the following effects of association are observable:

Ease of learning is increased,

I. If two or more successive syllables have the same initial consonant;

II. If two successive syllables form a rhyme;

III. If two successive syllables contain the same vowel or diphthong;

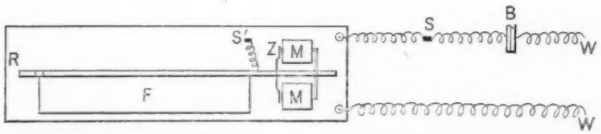
IV. If the final consonant of a syllable is the same as the initial consonant of the syllable immediately following;

V. If two or more syllables form a word or phrase, or if the syllable itself is a word.

VI. Unusual combinations and those especially difficult to pronounce were a hindrance to learning.

VII. Rhythm was found to have a distinctly favorable influence upon learning; syllables which had once formed part of a metrical foot tending to be associated more closely in all future combinations than syllables not so united.

To the authors of all this detailed and laborious work upon the material and method of memory work, the thanks of later investigators are due, and with this material, nonsense syllables, formed and arranged in accordance with the results of Müller and Schumann and altered so as to adapt them to the English language, the first experiments of the present problem were made.



Z = ⟨-shaped piece of metal.
B = battery.
S = switch.
M = magnets.
R = rotating bar.
F = shutter.
S′ = spiral spring.
W = wires leading to clock.

Description of Apparatus.

An automatic shutter, devised by Dr. E. C. Sanford, was used as the means of presenting the different series to the subject. This consisted of a board which could be tilted at any convenient angle, to which was fixed by brass supports a rotating bar. To this was fastened a strip of pasteboard of

convenient size. At the end of the bar were a pair of magnets, brought into connection with the rod by an (-shaped piece of iron.

An electric circuit being made, the attraction of the heaviest part of the metal toward the centre of the magnets caused the rotation of the bar and raised the strip of pasteboard. A light spiral spring fastened to an upright screw regulated the force of the movement, and threw the shutter back when the circuit was broken.

This shutter was electrically connected with a pendulum clock movement, to which were attached two commutators, each consisting of a rubber disc having eighty degrees of brass let into the circumference. Connection was made by two strips of metal fastened to the framework, and so bent as to touch the discs. The clock movement was so adjusted that each disc made one complete revolution in ninety seconds, and in such relation to each other that the circuit was made in one, two seconds earlier than in the other. The former was connected with an ordinary telegraph sounder and the other with the shutter. The clock being set in motion, a warning signal was given to the subject by the sounder, and two seconds later the shutter was raised and remained up for twenty seconds, the warning signal being repeated two seconds before its fall. The clockwork was placed in a separate room, and wires carried across to the shutter, in order that the attention of the subject might not be distracted by the ticking. A switch was introduced into the circuit, so that the interval of the break could be doubled or tripled if desired.

In the present research two points in the problem have been considered:

I. To investigate the complex of throat, tongue and lip movements involved in articulation, and to determine their influence upon the memory of syllables.

II. To investigate the muscle memory proper, *i. e.*, memory of movements.

In carrying out the proposed series of experiments, conditions were made as normal as possible consistently with the demands of experimentation. The subject was comfortably seated in a well-lighted, quiet room and a screen placed be-

tween him and the experimenter, so that extraneous ideas might be excluded as far as possible.

Experiments of the First Series.

The first experiment proposed was to find some means of inhibiting the action of the muscles involved in articulation, in order to compare the series thus learned with those learned under normal conditions.

Various means of inhibiting the movement of the muscles of the throat and mouth were tried. The subject was required to memorize while counting aloud,—one, two, three, one, two, three,—practice being continued until the counting became as nearly automatic as possible. Similar experiments were also tried, using a sustained musical note as the means of inhibition. The syllable *sol* was used as inhibiting action in a greater number of muscles than any other syllable used in musical notation.

In a series of one hundred experiments, each with the counting and sustained musical note, the per cent. of difference in the results was so small as to be practically negligible. The counting was finally adopted as the better method, because unmusical subjects proved to be somewhat diffident about sustaining a musical note, and so required more preliminary practice to overcome the distraction of attention due to this cause.

Each series of syllables was shown for twenty seconds, the subject being requested to repeat aloud as many as he could remember as soon as the shutter was closed. Errors were recorded under three heads :

I. Displacements in the order of the series. II. Wrong syllables. III. Forgotten syllables.

Under this last heading a subdivision into syllables omitted from portions of the series, and those forgotten at the end of the series, was made. This was done for the purpose of checking any tendency on the part of the subject to give more attention to one part of the series than another, the record of errors immediately showing any tendency to devote attention to the first five or six syllables instead of reading the whole series evenly. The subject was always experimented on at

the same hour of the day, and as nearly as possible under the same conditions of health, fatigue, exercise, etc., a record being kept of any deviation from the usual conditions.

The actual experiments from which results have been tabulated were made upon five subjects, one of whom was a trained psychologist, two had had several years of general practice in psychological experimentation, one was entirely unaccustomed to psychological work, and one, though unpracticed in psychological work, was of scientific training in biological work. All were given a sufficient amount of special practice to render the counting as nearly automatic as possible, and to reduce the mean variation of their records to a minimum. The daily hours of experimentation for each person were the same, an important precaution, as the memory curve varies greatly at different hours of the day.[1]

Each subject was given one hundred syllables, that is, ten series consisting of ten syllables each, at one sitting. This number was decided upon after various trials, which proved that a greater number of experiments at one time brought in an element of fatigue which rendered the record unreliable. At first, series with and without counting were alternated, but as this was found to produce interference on account of a tendency of the subject to count during the learning of series to be learned without counting, a change was made to the method of giving ten series with counting on one day, and ten series without counting on the following day. No series was ever repeated, as after once having been recited the auditory element was introduced. A careful record was kept of the physical and mental condition of the subject, and any series showing a marked degree of variation from the normal, which could be accounted for as the result of fatigue, inattention or extraneous disturbance, was excluded from the final averages. Each subject was requested at the close of an experiment to report any introspective observations of chance associations, such as nicknames or suggested words, and especially anything connected with the motor images. Many valuable hints were gained in this way. The following fact

[1] Cf. Bergström, Am. Journal of Psychology, p. 245.

was reported by all five subjects. At first, the counting produced actual inhibition of the motor image as well as of the overt act. To illustrate this, let anyone try the experiment, quoted by Prof. James[1] from Stricker, of trying to pronounce mentally the word "bubble" with the lips held widely apart so as to effectually prevent any attempt at actual pronunciation, or holding the throat open, as in yawning, attempt to mentally pronounce "giggle." It will be found that at first the mental image is blurred and indistinct. After practice, however, the motor idea became separable from the actual muscular movements, and it became possible to pronounce the syllables mentally with greater or less distinctness, while the muscles through which the motor idea would normally discharge were actually occupied in the movements of counting.

None of the five subjects exhibited the distinct types of visual, auditory and motor memories, so emphasized by Ribot and the French school of psychologists, but two of them, brother and sister, showed a somewhat marked predominance of the motor element, as is shown by the tables, and these two complained of some blurring of the mental pronunciation, especially if the combination of letters was an unusual one, or presented marked difficulty of pronunciation.

The presence of the motor image of the syllables during the counting was also shown by a tendency of the syllables to interpolate themselves in the midst of the counting. Cases of this occurred repeatedly in all five subjects, most frequently in the slight breaks of the counting caused by taking breath, but also at other times. In a few cases, the subject when questioned at the close of a series had no recollection of the interpolation. Whether there was consciousness of the error at the time it was committed cannot be stated, as no questions were asked until after the series had been recited.

The following tables are based on the record of the total number of errors made by each subject for one thousand syllables, the vertical columns showing the number of errors for each series of ten, taken in the order of presentation. The

[1] "Psychology," Vol. II, p. 63.

footing of the vertical columns shows the average error for each day's record of one hundred syllables. The averages taken horizontally give the average of error for the series taken in the order of their presentation, *i. e.*, for the total number of series presented, first, second, third, etc. The summation table shows the percentage of difference in the series due to the counting.

Subject J. P. H. Table showing the errors for 100 series of nonsense syllables with pronunciation inhibited by counting.

Dec. 10.	13.	16.	20.	Jan. 3.	7.	9.	14.	24.	28.	Av.
6	7	8	8	6	8	7	7	9	7	7.3
8	7	9	9	8	8	8	10	8	9	8.4
8	8	8	8	8	8	8	7	10	8	8.1
8	9	8	8	8	10	8	8	8	6	8.1
6	6	8	9	8	8	8	8	8	7	7.6
5	8	7	8	7	6	9	8	8	8	7.4
6	8	8	7	7	7	7	9	8	7	7.4
6	8	7	8	8	9	8	8	8	9	7.9
8	8	9	8	8	8	8	6	8	10	8.1
8	7	8	8	8	10	8	8	8	6	7.9
6.9	7.6	8.0	8.1	7.6	8.2	7.9	7.9	8.3	7.7	7.82

Subject J. P. H. Table showing the errors for 100 series of nonsense syllables under normal conditions.

Dec. 12.	19.	Jan. 8.	10.	15.	16.	21.	22.	25.	29.	Av.
6	5	5	6	7	8	7	7	7	7	6.5
6	6	6	6	7	8	7	5	7	7	6.5
8	8	6	7	5	7	7	5	7	7	6.7
6	5	8	5	7	7	7	7	8	5	6.5
7	6	7	4	8	6	7	6	7	7	6.5
6	7	5	6	6	8	6	8	6	6	6.4
8	7	7	6	6	6	7	6	6	6	6.5
6	6	8	6	7	7	8	6	8	5	6.7
5	7	6	5	5	7	8	7	6	7	6.3
6	6	8	6	5	7	7	6	6	6	6.3
6.4	6.3	6.6	5.7	6.3	7.1	7.1	6.3	6.8	6.3	6.49

Table showing classification of errors given in two preceding tables.

SUBJECT, J. P. H.	(c)					(o)			
	F.	D.	W.	Total.		F.	D.	W	Total.
Dec. 10th	39	4	26		Dec. 12th	38	6	20	
" 13th	56	6	14		" 19th	36	2	25	
" 16th	50	6	24		Jan. 8th	42	2	22	
" 20th	57	7	17		" 10th	38	2	17	
Jan. 3rd	56	6	14		" 15th	37	3	23	
" 7th	57	3	22		" 16th	40	4	27	
" 9th	57	–	22		" 21st	40	4	27	
" 14th	58	3	18		" 22nd	39	3	21	
" 24th	56	6	21		" 25th	40	2	26	
" 28th	51	4	22		" 29th	36	–	27	
	537	45	200	782		386	28	235	649

(c) = series with counting; (o) = normal series; F. = syllables forgotten; D. = syllables displaced; W. = syllables wrong.

Subject E. C. S. Table showing the errors for 100 series of nonsense syllables with the pronunciation inhibited by counting.

Dec. 2.	3.	6.	10.	13.	19.	Jan. 3.	7.	16.	23.	Av.
4	7	7	7	5	3	5	8	5	8	5.9
8	6	8	6	8	6	6	5	5	7	6.5
7	7	6	8	5	4	7	7	6	8	6 5
9	6	8	6	8	6	7	7	4	5	6.6
7	7	9	5	8	5	6	10	7	7	7.1
5	7	10	5	8	7	5	7	7	7	6.8
7	6	8	7	6	8	7	7	8	6	7.0
7	7	8	7	7	6	4	4	7	8	6.5
8	6	7	7	7	8	7	6	6	8	7.0
10	5	8	8	7	4	7	7	8	7	7.1
7.2	6.4	7.9	6.6	6.9	5.7	6.1	6.8	6.3	7.1	6.70

Subject E. C. S. Table showing the errors for 100 series of nonsense syllables under normal conditions.

Dec. 2	5.	6.	9.	12.	17.	20.	Jan. 6.	9.	21.	Av.
4	5	7	5	4	6	3	5	2	5	4.6
5	7	7	5	6	6	4	8	5	5	5.8
7	7	6	7	6	5	4	6	6	5	5.9
7	7	8	5	3	6	6	5	4	6	5.7
6	6	7	6	4	4	5	5	4	4	5.1
7	5	5	7	3	5	6	5	6	5	5.4
7	7	4	5	5	5	7	6	4	5	5.5
6	7	6	4	7	4	6	5	7	5	5.7
7	5	5	7	6	7	4	3	5	4	5.3
8	5	5	4	5	6	4	8	4	5	5.4
6.4	6.1	6.0	5.5	4.9	5.4	4.9	5.6	4.7	4.9	5.44

Table showing classification of errors given in two preceding tables.

Subject, E. C. S.	(c)					(o)			
	F.	D.	W.	Total.		F.	D.	W.	Total.
Dec. 2nd	51	4	17		Dec. 2nd	34	6	24	
" 3rd	25	7	32		" 5th	21	11	29	
" 6th	38	13	28		" 6th	20	11	29	
" 10th	31	6	29		" 9th	23	8	24	
" 13th	27	1	41		" 12th	19	5	25	
" 19th	27	5	25		" 17th	17	1	36	
Jan. 3rd	38	9	14		" 20th	25	7	17	
" 7th	20	9	39		Jan. 6th	12	7	37	
" 16th	23	4	36		" 9th	18	8	21	
" 23rd	29	9	33		" 21st	20	2	27	
	309	67	294	670		219	66	269	544

Subject E. H. L. Table showing the errors for 100 series of nonsense syllables with pronunciation inhibited by counting.

Dec. 7, 9	11.	13.	18.	21.	Jan 2.	6.	9.	15.	18.	Av.
5	5	8	3	6	3	4	2	3	4	4.3
5	4	4	5	4	5	4	3	5	6	4 5
5	7	6	5	6	8	8	5	7	5	6.2
6	6	5	9	8	5	6	7	6	3	6.1
9	5	5	8	6	3	5	5	5	4	5.5
5	6	6	6	4	5	3	5	5	4	4.9
8	7	6	5	6	9	7	4	3	3	5.8
6	6	5	7	5	6	5	4	4	7	5.5
9	6	6	5	5	5	3	5	6	9	5.9
8	5	7	8	9	7	8	5	4	7	6.8
6.6	5.7	5.8	6.1	5.9	5.6	5.3	4.5	4.8	5.2	5.55

Subject E. H. L. Table showing the errors for 100 series of nonsense syllables learned under normal conditions.

Dec. 7, 9	12.	17.	19.	23.	Jan. 4.	7.	11.	13.	16.	Av.
4	5	4	4	3	3	1	4	4	2	3.0
2	6	4	5	4	4	2	5	2	4	3.8
7	8	5	3	5	6	3	3	4	5	4.9
7	4	4	2	4	6	2	6	5	6	4.6
5	4	2	3	4	4	5	5	2	2	3.6
6	4	6	2	4	8	6	3	4	7	5.0
5	5	1	3	5	6	5	5	1	1	3.7
5	3	5	5	3	4	5	3	3	6	4.2
4	8	5	5	4	4	5	4	2	5	4.6
5	6	5	4	5	5	1	4	6	4	4.5
5.0	5.3	4.1	3.5	4.1	5.0	3.5	4.2	3.0	4.2	4.19

Subject E. H. L. Table showing classification of errors given in two preceding tables.

Subject. E. H. L.	(c) F.	D.	W.	Total.		(o) F.	D.	W.	Total.
Dec. 7 & 9	50	1	15		Dec. 7 & 9	39	2	9	
" 11th	32	16	9		" 12th	37	2	14	
" 13th	32	10	16		" 17th	31	5	5	
" 18th	41	4	16		" 19th	28	2	5	
" 21st	36	10	13		" 23rd	32	3	6	
Jan. 2nd	45	2	9		Jan. 4th	37	3	10	
" 6th	47	1	5		" 7th	30	1	4	
" 9th	27	9	9		" 11th	33	3	6	
" 15th	35	2	11		" 13th	19	4	7	
" 18th	29	7	16		" 16th	27	3	12	
	374	62	119	555		313	28	78	419

Subject C. G. Table showing errors for 100 series of nonsense syllables with pronunciation inhibited by counting.

Dec. 11.	13.	18.	20.	Jan. 2.	4.	7.	11.	15.	17.	Av.
6	7	10	8	10	9	10	6	7	8	8.1
8	7	10	5	7	7	8	6	7	8	7.3
10	8	7	7	7	7	6	7	8	8	7.5
8	8	8	10	6	10	6	9	6	8	7.9
7	6	10	10	7	6	8	7	6	7	7.4
6	8	7	8	8	7	8	5	7	7	7.2
7	5	7	8	6	9	7	6	5	7	6.7
9	7	9	7	8	8	8	7	7	8	7.8
9	6	10	7	8	8	5	9	7	8	7.7
9	7	7	7	5	7	7	7	8	7	7.1
7.9	6.9	8.5	7.7	7.2	7.8	7.4	6.9	6.8	7.6	7.47

Subject C. G. Table showing errors for 100 series of nonsense syllables learned under normal conditions.

Dec. 12.	14.	19.	21.	Jan. 3.	7.	9.	13.	16.	18.	Av.
5	5	7	6	6	6	6	1	5	6	5.3
8	4	6	7	7	3	6	7	5	6	5.9
7	5	7	5	5	7	6	5	4	7	5.8
7	4	6	7	6	6	8	5	7	5	6.1
7	7	6	3	4	3	4	3	7	7	5.1
4	5	6	7	5	6	6	5	6	5	5.5
5	7	7	7	6	6	4	5	5	5	5.7
5	5	6	6	6	5	7	6	7	7	6.0
7	5	8	8	7	7	5	5	5	7	6.4
4	3	7	7	6	4	5	5	5	6	5.2
5.9	5.0	6.6	6.3	5.8	5.3	5.7	4.7	5.6	6.1	5.7

Subject C. G. Table showing classification of errors in two preceding tables.

	(c)			Total.		(o)			Total.
	F.	D.	W.			F.	D.	W.	
Dec. 11th	66	5	8		Dec. 12th	48	6	5	
" 13th	60	3	6		" 14th	42	3	5	
" 18th	75	3	7		" 19th	53	6	7	
" 20th	70	6	1		" 21st	51	4	8	
Jan. 2nd	60	4	8		Jan. 3rd	49	1	8	
" 4th	66	7	5		" 7th	36	7	10	
" 7th	63	2	9		" 9th	45	–	12	
" 11th	62	1	6		" 13th	33	4	10	
" 15th	62	4	2		" 16th	47	3	6	
" 17th	63	6	7		" 18th	40	1	20	
	647	41	59	747		445	35	91	570

Subject R. G. Table showing errors for 100 nonsense syllables with pronunciation inhibited by counting.

Jan. 26.	28.	30.	Feb. 7.	11.	24.	Mar. 3.	9.	23.	Apr. 3.	Av.
7	7	8	4	7	6	4	4	1	4	5.2
7	6	5	4	3	4	0	1	5	3	3.8
8	8	5	5	6	5	3	4	3	1	4.8
8	9	7	6	6	7	3	8	2	1	5.7
4	4	7	7	7	6	4	4	3	3	4.9
5	4	7	7	7	5	8	4	5	2	5.4
7	4	5	6	8	4	4	4	6	1	4.9
5	5	5	6	7	4	7	3	7	2	5.1
6	6	5	6	7	2	6	6	4	1	4.9
5	5	5	4	3	2	5	8	3	0	4.0
6.2	5.8	5.9	5.5	6.1	4.5	4.4	4.6	3.9	1.8	4.87

Subject R. G. Table showing errors for nonsense syllables under normal conditions.

Jan. 24.	27.	29.	Feb. 10.	18.	25.	Mar. 10.	24.	31.	Apr. 4.	Av.
6	4	5	4	6	4	1	4	2	0	3.6
6	2	4	5	5	5	4	2	3	0	3.6
9	3	4	1	7	4	3	0	0	0	3.1
6	3	5	8	7	4	3	0	0	2	3.8
5	4	6	5	4	4	1	4	3	2	3.8
8	3	4	7	2	4	3	3	2	1	3.7
3	5	1	3	5	3	1	1	1	0	2.3
5	7	6	3	2	0	2	3	1	0	2.9
7	7	6	6	0	4	1	0	0	0	3.1
4	3	4	3	2	3	0	1	4	0	2.6
5.9	4.1	4.5	4.7	4.0	3.5	1.9	1.8	1.6	5	3.25

Subject R. G. Table showing classification of errors given in two preceding tables.

	(c)			Total.		(o)			Total.
	F.	D.	W.			F.	D.	W.	
Jan. 26th	50	1	11		Jan. 24th	38	7	14	
" 28th	39	7	12		" 27th	30	4	7	
" 30th	28	2	19		" 29th	27	6	12	
Feb. 7th	35	2	18		Feb. 10th	29	6	12	
" 11th	34	3	24		" 18th	28	2	10	
" 24th	31	3	11		" 25th	20	3	12	
Mar. 3rd	30	3	11		Mar. 10th	10	1	8	
" 9th	24	7	15		" 24th	8	3	5	
" 23rd	27	–	12		" 31st	8	3	5	
Apr. 3rd	7	2	9		Apr. 4th	4	–	1	
	315	30	142	487		202	35	88	325

SUMMATION TABLE FOR NONSENSE SYLLABLES.

J. P. H.	(c)	69	76	80	81	76	82	79	79	83	77	7.82
	(o)	64	63	66	57	63	71	71	63	68	63	6.49
											D. = 13.3%	
E. C. S.	(c)	72	64	79	66	69	57	61	68	63	71	6.70
	(o)	64	61	60	55	49	54	49	56	47	49	5.44
											D. = 12.6%	
E. H. L.	(c)	66	57	58	61	59	56	53	45	48	52	5.55
	(o)	50	53	41	35	41	50	35	42	30	42	4.19
											D. = 13.6%	
C. G.	(c)	79	69	85	77	72	78	74	69	68	76	7.47
	(o)	59	50	66	63	58	53	57	47	56	61	5.70
											D = 17.7%	
R. G.	(c)	62	58	59	55	61	45	44	46	39	18	4.87
	(o)	59	41	45	47	40	35	19	18	16	5	3.25
											D. = 16.2%	

D. = percentage of difference between series with counting and normal series.
(c) = series with counting.
(o) = series under normal conditions.

A study of these tables shows in all subjects a gradual diminution of error due to practice. An examination of the curves given on pages 473 and 474 shows that in four of the subjects, this was fairly uniform. R. G.'s record, however, shows a very sudden descent of the error curve toward the end. A reference to the dates of the experiments and the fact that during

the latter part of March R. G. served as subject of another research in which the same series of nonsense syllables was used, and received considerable practice in memorizing, furnish an explanation of this deviation from the other results.

The method of each subject was carefully noted, and test series, in which the subject was required to memorize aloud were taken. Although these series were taken primarily simply as a study of method, the quantitative variation for the different subjects due to the addition of the auditory element and emphasizing of the throat movements are so marked that a brief summary of them is given. Five tests, consisting of ten series of ten syllables each, were taken for each subject.

Average	error	for	E. H. L.	= 3.30
"	"	"	C. G.	= 4.55
"	"	"	E. C. S.	= 4.58
"	"	"	J. P. H.	= 6.38
"	"	"	R. G.	= 2.20

Comparing these results with those given in the previous tables, we find a positive improvement of memory, amounting—

For	E. H. L.	to	8.9	per cent.
"	C. G.	"	11.5	" "
"	E. C. S.	"	8.6	" "
"	J. P. H.	"	1.1	" "
"	R. G.	"	10.5	" "

Some allowance must be made in the case of R. G., as these records were taken toward the close of the series of experiments, and were therefore affected by the extraneous practice before mentioned.

It will be remembered that from the beginning no attempt was made to regulate the method of learning the syllables by the introduction of artificial conditions, each subject being left free to pursue the method most natural to him. The number of times the syllables were read during the twenty seconds was therefore dependent upon the individual preference of the subject. The average number of readings for each subject was as follows:

E. C. S., three or four readings during twenty seconds.
E. H. L., two or less " " " "
R. G., rarely more than one reading during twenty seconds.
G. G., two or three readings during twenty seconds.
J. P. H., four or four and a half readings during twenty seconds.

Arranging these results in order of the frequency of reading and comparing them with the percentage of error for each subject, gives the following tables:

	Average Error with Counting.	Average Error in Normal Series.	Read Series.
R. G.	4.87	3.25	1+
E. H. L.	5.55	4.19	2+
E. C. S.	6.70	5.44	3+
C. G.	7.47	5.70	3+ [1]
J. P. H.	7.82	6.49	4+

This result was unexpected, but is so striking as to suggest that the retentiveness which has been ascribed by Ebbinghaus and later experimenters may be due to the amount of time given to each syllable and that the practical problem to be solved for pedagogy is that of distribution of time in relation to the number of repetitions rather than a simple question of the number of repetitions.

While the tables show for every subject an increase of error, varying from 12.6% to 17.7%, due to the introduction of the counting, it still remains doubtful whether the difference can be attributed to the inhibitory effect of the counting upon the muscles, which under normal conditions would furnish the motor expression of the syllables, or to a diversion of attention caused by the introduction of a new factor. This difficulty was fully recognized and various attempts made to meet it. One, which, however, proved unsatisfactory, is noted here, although the test which finally proved most satisfactory is taken up in connection with the later experiments made with the manual alphabet as material. It seemed that if any series could be devised in which the motor idea was originally absent, but might be introduced later, or if this series were of such a character that it could be directly compared with the nonsense syllables series, a verification of the results already obtained might be found.

In any series, whether of figures, letters or syllables, that could be named, the motor idea must be present, therefore the only way of obtaining a series to compare with those already given was to use something which should be unnamed

[1] Toward the close of the experiments this subject changed his method to slower reading.

by the subject. Various Oriental alphabets, and the Braille system used by the blind, were tried, but were all found open to objection. Some were too complicated to be reproduced within the given time, and others suggested objects which could be named. Finally a series composed of a curve and straight lines in different positions was adopted. A complete set of experiments, one hundred series, was carried out with two subjects, but the results were not such as to justify a continuance in the same line. In one subject the percentage of error fell midway between the series with counting and the normal series instead of running parallel with it, as was expected. In the other it differed but a small per cent. from the normal series. This result was evidently due to the imperfection of the material, as it proved suggestive of so many mnemonics that the naming element was by no means excluded. The subject using the most mnemonics had the lesser percentage of error.

A summary of the results derived from an examination of the tables includes the following points :

I. The number of syllables displaced is for every subject less than either of the other two classes of error.

II. For all subjects except one (E. C. S. in the normal series), the number of syllables forgotten exceeds those given wrongly.

III. There are no marked differences in the proportion of three classes of error in the series with counting and the normal series.

IV. The percentage of error is increased to an amount varying from 12.6% to 17.7% for different subjects by the addition of the counting.

In addition to these quantitative results, the study of errors, particularly that of the wrong syllables, furnishes much material that is suggestive. The wrong syllables may be grouped into three classes : I. Those which are mutilated forms of the original syllables. II. Syllables which have been transferred from earlier series, or are mutilations of syllables occurring elsewhere in the same series. III. A residual which can be included in neither of the above classes.

The first class, *i. e.*, mutilations of the original syllables, is the most numerous as well as the most interesting. Displacement of final and initial consonants occur about equally, and these are more numerous than displacements of the vowel.

In several subjects there has been observed a distinct tendency to displace these consonants in accordance with Grimm's law of the interchange of consonants, *i. e.*, *b* and *p*, *t* and *d* are interchanged. Unusual consonants, as final *j* or *h* or initial *x*, are frequently omitted, and in many cases the subject reported something forgotten which was hard to pronounce.[1]

In the study of the second class of wrong syllables, *i. e.*, those transposed from earlier series, great difficulty presented itself, the tracing back of syllables through a large number of series involving much labor and some uncertainty in the results, as syllables similar in sound and spelling were frequently confused. One fact, however, has been clearly deduced : there is a strong tendency of certain syllables to recur in successive series when actually present in only one or at most three series, *e. g.*, one syllable, *ceb*, was found to have been given thirteen times in one hundred series when it actually occurred but twice. This, however, was probably partly due to confusion with the syllable *ced*, which occurred three times during the one hundred series.

The third class of errors, which is numerically the smallest, has yielded no results.

Experiments of the Second Series.

For the second series of experiments an entirely new material was used. This consisted of the printed characters of the manual alphabet. The small cards[2] ordinarily used

[1] Experiments with series of syllables so arranged as to present special difficulties of pronunciation might furnish interesting results.

[2] These can be obtained from the National Exponent Publishing Co., 69 Lake street, Chicago.

in deaf mute institutions were cut apart and arranged in series of five and ten. *J* and *Z* were excluded, so that with the character &, twenty-five characters indicating positions of the hand were available. These were so arranged that each position occurred the same number of times in ten series, no position occurring twice in the same series.

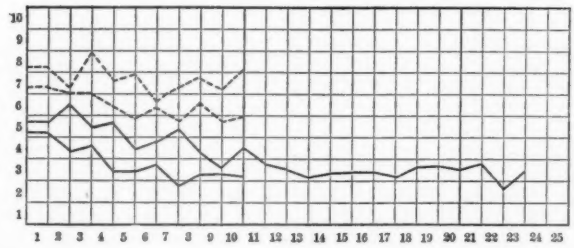
Each subject received sufficient preliminary training to enable him to form the characters with a reasonable degree of facility. The same method of presentation was used as in the case of the nonsense syllables. In the series of five the same intervals, *i. e.*, twenty seconds' exposure and seventy seconds' intermission, were used. In the series of ten, the time of exposure remained the same, but the intermission was doubled to allow for the slower reproduction than in the case of the nonsense syllables. The subject was given at one sitting ten successive series, which he was asked to memorize visually, and to reproduce by forming the characters with his hand as soon as the shutter fell. A series running parallel with this was also taken, in which all conditions remained the same, except that during the twenty seconds devoted to learning the series, the subject was required to form the characters with his hand in addition to the visual reading. These series were taken on alternate days, for the same reason as in the case of the nonsense syllables, *i. e.*, to avoid the interference which occurred when the two series were alternated at one sitting. None of the subjects was familiar with the manual alphabet, and so far as possible the same conditions of experimentation were observed throughout. The same method of recording errors was used as in the experiments with nonsense syllables.

Records were taken on seven subjects, three of whom, E.C. S., E. H. L. and J. P. H., had served as subjects throughout the work with the nonsense syllables. The tables are formed on the same basis as those for the nonsense syllables, the vertical columns showing the errors of the successive series for each day's record, and the horizontal reading the errors of the successive series taken in numerical order for successive days. The summation table shows the decrease in percentage of error for each subject when the characters were

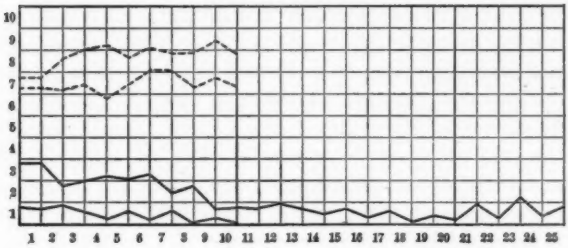
formed with the hand during the learning of the series, and also of a third series, in which the subject was required to count while learning a series visually. This latter series was not alternated with the others, but was taken continuously after the other records were completed. This is more clearly shown by a reference to the curves given on page 474. For the sake of brevity, these series will be referred to as visual and motor series and series with counting.

The curves are plotted on the basis of the total number errors, each point in the curve representing the average error for a series of ten experiments, *i. e.*, for one hundred nonsense syllables or one hundred characters of the manual alphabet, except in series of five, where the calculation is based upon fifty instead of one hundred characters. The figures of the vertical column indicate the number of errors and the horizontal the number of series of ten experiments. The dotted lines represent the curves for the nonsense syllables, the upper curve being for the series taken with counting and the lower the corresponding normal series. The curves formed by the continuous lines represent the manual alphabet series, the upper being for the visual and the lower for the motor series. The continuation of the curve from 10 to 20 shows the effect of the counting on the manual alphabet series, and from 20 onward the effect of discontinuing the counting in diagrams I and II. In V, VI and VIII the counting begins at seven and is discontinued from thirteen onward.

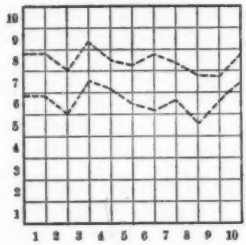
I. Subject E. C. S.



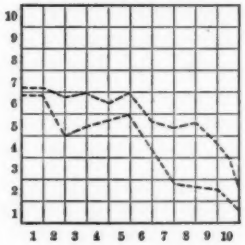
II. Subject J. P. H.



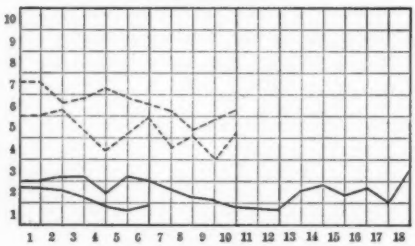
III. Subject C. G.



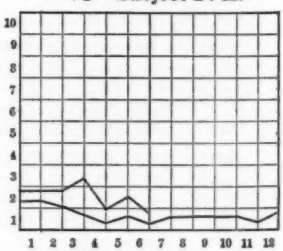
IV. Subject R. G.



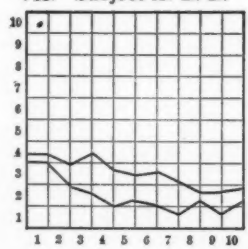
V. Subject E. H. L.



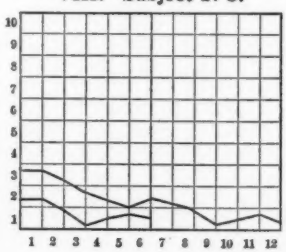
VI. Subject D. H.



VII. Subject A. E. E.



VIII. Subject T. C.



Preliminary record of E. C. S. Series of five.

Motor Series.					Total.	Visual Series.					Total.
Feb. 27.	28.	Mar. 3	7.	10.		F'b. 21	24.	Mar. 2	5.	9.	
0	0	0	1	0	1	1	2	0	0	0	3
1	1	0	0	0	2	1	1	0	1	0	3
0	0	1	0	0	1	2	1	1	0	0	4
0	0	0	0	0	0	2	3	1	1	1	8
1	0	0	1	1	3	2	3	1	0	0	6
0	1	1	0	0	2	2	4	2	0	0	8
2	2	0	2	1	7	3	1	1	2	0	7
0	2	0	0	0	2	3	3	0	1	0	7
1	1	0	2	0	4	2	0	3	0	0	5
2	1	1	1	2	7	4	3	0	0	0	7
7	8	3	7	4	29	22	21	9	5	1	58

Record of E. C. S. Manual alphabet, visual series of ten.

Mar. 13.	19.	24.	27.	31.	Apr. 3.	15.	18.	23.	25.	Av.
3	4	2	4	5	4	3	2	0	0	2.7
4	6	6	2	0	2	2	4	2	5	3.3
5	5	6	6	3	3	3	2	5	2	4.0
7	6	4	4	4	3	4	3	4	4	4.3
4	4	0	8	4	6	6	5	4	4	4.5
5	5	6	5	5	0	6	2	2	4	4.0
7	5	8	3	2	4	5	3	4	5	4.6
6	5	5	2	1	1	2	2	0	5	2.9
3	8	5	7	4	6	3	5	2	1	4.4
3	7	4	6	6	6	7	3	4	5	5.1
4.7	5.5	4.6	4 7	3.4	3.5	4.1	3.1	2.7	3.5	3.98

Record of E. C. S. Manual alphabet, motor series of ten.

Mar. 16.	20	26.	30.	Apr. 2.	4	17.	21.	24.	26.	Av.
2	1	4	0	4	4	1	1	3	0	2.0
4	4	6	0	0	2	0	0	2	2	2.0
3	2	4	2	1	2	1	2	2	2	2.1
5	5	4	2	2	1	1	2	2	3	2.7
5	6	4	3	3	6	3	2	1	3	3.6
4	3	2	3	3	1	3	1	4	2	2.6
6	3	1	3	1	5	3	3	3	2	3.0
5	3	2	3	5	3	3	2	3	2	3.0
4	5	4	5	3	2	2	5	2	2	3.4
4	3	5	3	2	1	2	5	2	3	3.0
4.2	3.5	3.6	2.4	2.4	2.7	1.8	2.3	2.4	2.1	2.74

Record of E. C. S. Manual alphabet, series of ten with counting.

Apr. 28.	29.	30.	May 1.	2.	4.	5.	7.	8.	9.	Av.
0	0	2	2	2	1	1	3	1	1	1.3
3	3	1	0	0	1	1	5	4	2	2.0
4	1	3	2	1	2	2	0	3	3	2.1
4	3	3	2	3	3	3	4	4	2	3.1
2	4	2	2	3	3	2	1	3	2	2.4
3	3	2	3	3	4	3	1	3	2	2.7
3	2	2	3	3	3	2	1	3	4	2.6
4	3	2	3	3	2	3	4	1	4	2.9
3	4	2	3	4	4	3	3	3	2	3.1
3	3	2	3	3	2	2	4	1	2	2.5
2.9	2.6	2.1	2.3	2.5	2.5	2 2	2.6	2.6	2.4	2.47

Preliminary record of A. C. E. Series of five, manual alphabet.

Motor Series.					Total.	Visual Series.					Total.
Mar. 22	23.	25.	28.	31.		Mar. 17	18.	21.	24.	27.	
1	0	0	0	0	1	1	0	0	0	0	1
0	0	0	0	0	0	2	3	2	0	0	7
0	1	0	0	0	1	1	0	2	0	0	3
1	0	0	0	0	1	2	1	3	0	0	6
0	0	0	0	0	0	3	3	1	2	1	10
1	0	0	0	0	1	3	3	1	1	1	9
1	0	1	2	0	4	1	2	3	1	0	7
0	1	0	0	0	1	2	4	2	2	2	12
1	1	0	0	1	3	3	3	0	1	3	10
1	3	0	0	0	4	3	3	0	0	0	6
6	6	1	2	1	16	21	22	14	7	7	71

Percentage of error, 3.2%. Percentage of error, 14.2%.
Dif. = 11%.

Record of A. C. E. Manual alphabet, visual series of ten.

Apr. 3.	13.	17.	21.	24.	27.	29.	May 2.	5.	7.	Av.
2	1	3	0	0	0	1	0	0	0	.7
7	5	4	0	3	0	1	0	2	0	2.2
4	2	5	4	3	5	1	4	0	3	3.1
2	4	4	2	2	2	2	0	1	2	2.1
4	4	3	1	3	0	4	0	3	1	2.3
3	4	0	4	2	6	4	2	0	0	2.5
3	1	3	4	3	5	2	4	4	4	3.3
3	3	3	5	2	2	5	6	4	3	3.0
5	3	2	2	4	3	2	5	0	2	2.8
2	2	4	5	3	2	0	1	2	2	2.3
3.5	2.9	3.1	2.7	2.5	2.5	2.2	1.6	1.6	1.7	2.43

Record of A. C. E. Manual alphabet, motor series of ten.

Apr. 1.	4.	16.	18.	23.	25.	28.	May 1.	4.	6.	Av.
3	1	1	0	0	2	1	0	0	0	.8
3	2	2	0	0	0	0	0	1	1	.9
2	2	2	1	1	0	0	1	0	0	.9
2	2	3	0	2	2	1	2	2	1	1.7
4	1	1	0	2	3	1	0	0	0	1.2
3	2	2	1	3	0	0	1	1	0	1.3
3	3	1	2	3	1	1	0	0	0	1.4
3	3	1	1	0	1	2	3	2	4	2.0
4	3	1	3	1	0	1	2	0	3	1.8
3	0	4	2	2	2	2	2	0	1	1.8
3.0	1.9	1.8	1.0	1.4	1.1	.9	1.1	.6	1.0	1.38

Record of J. P. H. Manual alphabet, visual series of five.

Feb. 8.	12.	15.	19.	25.	29.	Mar. 4.	7.	11.	14.	Av.
2	1	2	2	2	2	1	2	0	1	1.5
2	2	0	1	2	1	1	2	0	0	1.1
3	2	2	3	3	2	2	3	2	1	2.3
4	3	0	1	1	2	1	0	0	0	1.2
2	0	3	3	3	3	0	1	1	1	1.7
5	3	3	3	5	1	1	0	2	0	2.3
1	2	2	3	2	3	1	3	0	1	1.8
2	2	2	1	1	4	3	1	0	1	1.7
4	1	2	1	0	3	2	3	1	3	2.0
3	2	3	3	2	1	1	2	1	0	1.8
2.8	1.8	1.9	2.1	2.1	2.2	1.3	1.7	.7	.8	1.74

Record of J. P. H. Manual alphabet, motor series of five.

Feb. 11.	14.	18.	21.	23.	Mar. 3.	6.	10.	13.	17.	Av.
0	1	0	0	2	0	0	1	0	0	.4
0	1	1	2	0	1	1	1	0	0	.7
1	0	0	0	0	0	0	0	0	0	.1
3	3	1	2	1	0	1	0	0	0	1.1
0	1	0	1	0	0	0	0	0	0	.2
1	0	1	1	1	1	1	1	0	0	.7
1	1	1	0	2	0	0	2	1	3	1.1
1	0	2	1	2	1	2	0	0	0	.9
1	0	1	1	0	0	0	0	2	0	.5
1	1	0	1	1	0	1	1	0	0	.6
.9	.8	.7	.9	.9	.3	.6	.6	.3	.3	.63

Record of J. P. H. Manual alphabet, series of five with counting.

Mar. 20.	24.	25.	27.	28.	31.	Apr. 1.	2.	4.	6.	Av.
0	0	0	1	0	0	0	0	0	0	.1
0	0	0	0	0	0	0	0	0	0	.0
2	1	2	0	4	0	0	1	0	0	1.0
1	0	0	0	0	1	2	0	0	0	.4
0	0	1	0	2	0	0	0	0	0	.3
1	2	0	0	0	1	2	0	2	0	.8
1	3	2	1	0	0	0	0	0	1	.8
2	2	0	0	1	0	1	0	0	0	.6
0	1	2	0	0	0	0	0	0	0	.3
0	0	0	2	0	0	0	0	0	0	.2
.7	.9	.7	.4	.7	.2	.5	.1	.2	.1	.45

Record of D. H. Manual alphabet, visual series of five.

Mar. 31.	Apr. 2.	4.	13	15.	16.	Sum.
2	2	3	3	1	0	11
2	2	3	0	0	1	8
0	2	3	1	2	0	8
2	3	2	0	0	2	9
3	0	2	0	1	2	8
1	1	3	0	1	0	6
2	3	2	0	3	0	10
3	1	2	1	2	0	9
2	3	1	4	3	1	14
1	1	2	0	2	1	7
1.8	1.8	2.3	.9	1.5	.7	90

Av. 1.50.

Record of D. H. Manual alphabet, motor series of five.

Mar. 30.	Apr. 1.	3.	14.	16.	17.	Sum.
0	0	0	0	2	0	2
3	2	2	1	0	0	8
1	1	0	0	0	1	3
0	0	0	1	0	1	2
2	2	0	0	2	0	6
1	0	2	0	1	0	4
2	1	0	1	1	0	5
1	1	0	1	0	1	4
1	2	2	1	0	0	6
3	2	1	0	0	0	6
1.4	1.1	.7	.5	.6	.3	46

Av. .76

Record of D. H. Manual alphabet, with counting.

Apr. 24.	25.	27.	28.	29.	30.	Sum.
0	0	0	0	0	0	0
1	1	0	2	0	0	4
0	0	1	1	1	0	3
2	1	0	0	0	0	3
0	1	0	1	1	1	4
1	0	0	0	1	2	4
1	2	0	1	0	0	4
0	0	2	0	1	0	3
1	1	2	0	0	0	4
0	0	1	1	1	1	4
.6	.6	.6	.6	.5	.4	33

Av. .55

Record of E. H. L. Manual alphabet, visual series of five.

Mar. 8.	20.	25.	30.	Apr. 3.	17.		Sum.
1	1	1	1	0	0		4
5	3	2	0	0	2		12
2	1	2	3	2	1		11
1	4	3	0	3	2		13
0	2	3	2	2	2		11
2	0	2	1	2	2		9
4	1	1	0	3	3		12
1	3	3	2	3	4		16
2	4	2	3	3	1		15
2	2	2	3	3	3		15
2.0	2.1	2.1	1.5	2.1	2.0		118

Av. 1.96

Record of E. H. L. Manual alphabet, motor series of five.

Mar. 18.	23.	27.	Apr. 1.	15.	22.		Sum.
1	1	1	0	0	0		3
0	2	1	0	1	0		4
3	3	2	1	2	0		11
1	1	0	1	0	0		3
1	1	2	0	0	1		5
4	0	1	0	1	1		7
3	1	1	1	1	2		9
3	1	1	2	1	2		10
0	0	1	2	0	2		5
0	4	1	2	1	1		9
1.6	1.4	1.1	.9	.7	.9		66

Av. 1.10

Record of E. H. L. Manual alphabet, series of five with counting.

Apr. 25.	27.	30.	May 1.	5.	6.		Sum.
0	1	0	0	0	1		2
1	1	1	0	2	0		5
2	1	1	2	0	0		6
2	1	1	2	1	1		8
2	2	2	0	2	0		8
2	2	1	0	2	2		9
3	1	2	1	0	2		9
2	2	1	1	1	2		9
2	1	2	2	1	1		9
2	1	1	1	0	0		5
1.8	1.3	1.2	.9	.9	.9		70

Av. 1.16

Record of T. C. Manual alphabet, visual series of five.

Mar. 25	30.	Apr. 1.	3.	14.	17.		Sum.
0	1	2	0	0	0		3
1	3	1	1	1	1		8
4	2	2	2	2	2		14
3	3	2	1	0	3		12
3	2	3	4	2	1		15
2	2	3	1	2	2		12
4	2	1	1	0	0		8
3	2	2	0	1	1		9
3	3	1	1	0	2		10
3	3	2	2	3	1		14
2.6	2.3	1.9	1.3	1.1	1.3		105

Av. 1.75

Record of T. C. Manual alphabet, motor series of five.

Mar. 27.	28.	31.	Apr. 2.	4.	15.		Sum.
1	1	0	0	0	0		2
1	1	0	0	1	0		3
2	0	1	2	0	1		6
2	1	1	0	1	0		5
0	2	0	0	0	0		2
1	1	0	2	1	1		6
3	1	0	0	1	0		5
1	1	1	0	0	0		3
1	0	2	1	1	1		6
1	1	2	0	1	0		5
1.3	.9	.7	.5	.6	.3		43

Av. .71

Record of T. C. Manual alphabet, series of five with counting.

Apr. 24.	25.	27.	28.	29.	30.		Sum.
1	0	0	0	0	0		1
1	0	0	0	0	0		1
1	1	0	1	1	2		6
1	1	1	0	0	1		4
2	1	0	0	0	0		3
1	1	0	0	2	0		4
1	1	0	0	1	0		3
1	1	1	0	0	0		3
1	1	0	1	2	1		6
2	2	1	2	0	0		7
1.2	.9	.3	.4	.6	.4		38

Av. .63

SUMMATION TABLE FOR THE MANUAL ALPHABET SERIES.

												Av.
E. C. S.	V.	47	55	46	47	34	35	41	31	27	35	3.98
	M.	42	35	36	24	24	27	18	23	24	21	2.74
	C.	29	26	21	23	25	25	22	26	26	24	
											D. = 12.4%	
A. C. E.	V.	35	29	31	27	25	25	22	16	16	17	2.43
	M.	30	19	18	10	14	11	9	11	6	10	1.38
											D. = 10.5%	
J. P. H.	V.	28	18	19	21	21	22	13	17	7	8	1.74
	M.	9	8	7	9	9	3	6	6	3	3	.63
	C.	7	9	7	4	7	2	5	1	2	1	
											D. = 22.2%	
								Sum.		Av.	%	
D. H.	V.	18	18	23	9	15	7	90		1.5	30.0	
	M.	14	11	7	5	6	3	46		.76	15.3	
	C.	6	6	6	6	4	5	33		.55	11.0	
										D. = 14.7%		
E. H. L.	V.	20	21	21	15	21	20	118		1.96	39.3	
	M.	16	14	11	9	7	9	66		1.10	22.0	
	C.	18	13	12	9	9	9	70		1.16	23.3	
										D. = 17.3%		
T. C.	V.	26	23	19	13	11	13	105		1.75	35.0	
	M.	13	9	7	5	6	3	43		.71	14.3	
	C.	12	9	3	4	6	4	38		.63	12.6	
										D. = 20.7%		

V. = visual series.
M. = motor series.
C. = series with counting.
D. = difference in % of error between visual and motor series.

TABLES SHOWING CLASSIFIC'N OF ERRORS FOR MANUAL ALPHABET.

Record of E. C. S.

MOTOR.			VISUAL.			COUNTING.		
F.	D.	W.	F.	D.	W.	F.	D.	W.
1	8	12	4	15	16	2	13	14
3	11	10	1	13	13	–	12	14
1	12	10	1	17	13	–	10	11
2	6	10	2	27	12	–	11	12
–	16	11	3	15	17	1	11	13
3	10	11	–	19	15	–	11	14
1	18	5	2	22	23	–	10	12
5	22	9	4	25	17	–	10	16
1	21	13	1	33	21	–	13	13
2	25	15	3	25	19	–	12	12
19	149	106	21	211	166	3	113	131

F.= characters forgotten; D.= characters displaced; W.= characters wrong.

Record of A. C. E.

MOTOR.			VISUAL.		
F.	D.	W.	F.	D.	W.
–	5	5	–	8	9
–	3	3	1	7	8
1	3	7	1	9	6
–	3	6	2	12	8
1	6	4	2	16	7
3	7	4	3	13	9
–	4	6	3	12	10
7	5	6	7	16	8
7	5	7	14	9	6
8	3	19	9	8	18
27	44	67	44	110	89

Record of J. P. H.

Motor.			Visual.			Counting.		
F.	D.	W.	F.	D.	W.	F.	D.	W.
1	5	3	16	2	10	–	3	4
4	–	4	6	3	9	–	3	6
3	1	3	6	3	10	1	3	3
3	1	5	3	8	10	–	1	3
4	3	2	7	7	7	–	4	3
1	1	1	4	8	10	–	–	2
–	2	4	3	2	8	–	1	4
1	1	4	1	3	13	–	–	1
–	3	–	–	–	7	–	–	2
1	–	2	–	–	8	–	–	1
18	17	28	46	36	92	1	15	29

Record of D. H.

Motor.			Visual.			Counting.		
F.	D.	W.	F.	D.	W.	F.	D.	W.
5	4	5	5	4	9	3	2	2
2	4	5	8	2	8	3	1	2
2	2	3	5	4	14	2	–	4
4	–	1	1	5	3	1	2	3
3	1	2	5	2	8	–	–	4
–	–	3	1	4	2	–	2	3
16	11	19	25	21	44	8	7	18

Record of E. H. L.

Motor.			Visual.			Counting.		
F.	D.	W.	F.	D.	W.	F.	D.	W.
–	8	8	–	14	6	8	5	5
4	1	9	9	1	11	6	2	5
2	3	6	14	1	6	7	1	4
6	1	2	7	2	6	2	2	5
6	–	1	13	4	4	4	2	3
6	–	3	10	6	4	4	3	2
24	13	29	53	28	37	31	15	24

Record of T. C.

Motor.			Visual.			Counting.		
F.	D.	W.	F.	D.	W.	F.	D.	W.
7	1	5	10	5	11	–	2	2
4	3	2	4	10	9	1	1	4
4	1	2	5	8	6	1	–	3
–	2	3	–	1	10	1	–	2
–	2	4	2	3	8	1	3	5
–	1	2	2	4	7	2	2	8
15	10	18	23	31	51	6	8	24

As in the experiments with the nonsense syllables, a study was made of the method of each subject, both from introspective report and the character of the errors.

E. C. S. showed the strongest tendency to mnemonics. There was at first an inclination to give names to the various characters, but this was resisted as introducing a source of error. Open and closed positions of the hand or the number of fingers pointing upward or downward, were then used as a means of classification. Later, a spatial mnemonic was strongly developed, the first and last and fifth and sixth positions being used as points of fixation. An incipient tendency to form the characters with the hand during the learning of the visual series was noticed, and after the characters became familiar, the subject occasionally could not remember whether in the series where motions were required the motions had been made or not, although, at first, a special effort was required to make them, and they were felt to be a hindrance to the visual learning. The preliminary record of the subject, however, shows 11.6% less of error for the motor series than for the visual. In the final record the difference in favor of the motor series was reduced to 11%. The change of method noted for the later series of nonsense syllables to a slower reading of the series was continued in the learning of the manual alphabet series, the series being read from two to two and one-half times during the twenty seconds of exposure. It is to be noted that the total number of errors is less and the relative number of displacements greater than

in the series of nonsense syllables. The smaller number of characters employed would seem to furnish a reason for this result, but the same relation did not hold for all subjects.

Subject A. C. E. A preliminary record taken with a series of five characters, showed a difference of 11% in favor of the motor series. The difference is reduced to 10.5% in the final record taken with a series of ten. There was with this subject a distinct consciousness of the advantage gained by introducing the motor element, and a much greater degree of confidence was shown in the motor than in the visual series. There was a strong tendency to make the movements during the learning of the visual series. In some instances there was a conflict between the visual and motor images, the statement being made, "It looks like this, but it feels like this." Although decision was sometimes made in favor of the visual image, the motor image was in the majority of cases the correct one. This subject was remarkable for the persistence of the memory images, being able to recall a series after considerable intervals of time had elapsed. In one case a series was correctly recalled after an interval of two hundred and seventy seconds, the time of exposure having been twenty seconds. In the later experiments the method of this subject was chiefly elimination, the possible characters being formed with the hand, and decision, guided partly by the feeling of the hand and partly by the visual image, called up simultaneously with the movement. The series was rarely read through more than once, and in some cases a series had to be thrown out because the subject failed to read it to the end. This record has the least percentage of error found in any case, showing for the motor series only 138 errors for one thousand characters, and for the visual series only 243 errors for the same number.

Subject J. P. H. Little conscious aid was derived by this subject from the introduction of the motor element, except in the practice series, when it at first seemed a help, the feeling of position seeming to reinforce the visual image. Later as the motions became more automatic, they seemed to the subject more of a hindrance than a help in so far as they were noticed at all. The record, however, shows a difference of

22.2% in favor of the motor series, and an incipient tendency to motion was especially marked. In a large number of cases the character was either partially or completely formed by the hand several seconds before it was recalled visually, and in a number of cases the character was correctly formed by the hand, but given up as forgotten by the subject. No visual attention was given to the hand by any subject after the first few practice series.

Subject D. H. This subject made from the first a strong effort to exclude all forms of mnemonics, and to make the memorizing purely visual. The making of the characters was a conscious effort, and in no case was the tendency to form the characters unconsciously, noted. The average number of times of reading the series was two and one-half.

Subject E. H. L. The introspective report of this subject shows the visual image to have been most prominent in consciousness, though during the motor series, the motor image was occasionally distinguished. Little use was made of mnemonics, though the relative positions of the characters were sometimes used as a means of recall. Attempts at naming were very infrequent, though occurring in a few cases.

Subject T. C. This subject showed a slight tendency toward naming the characters, and a somewhat uneven distribution of attention was noted, any character which appeared difficult receiving more attention. In the series in which the characters were not formed with the hand, the visual image was the only one noticed by the subject, and no case of unconscious reproduction of the characters was noted. In the motor series the motion of the hand followed the visual idea without consciousness of effort, but in no case did the motion precede the visual image. The average number of readings given to the series was two and one-half times.

The memory span of each subject was originally tested by a graded series, and in cases where great variability in the results occurred from the use of the longer series, the series of five was used as giving more satisfactory results, although preventing a direct numerical comparison with the series in which ten characters were used. A study of the distribution

of error, and comparison with the nonsense syllables series for each subject, gives the following results:

For E. C. S. displacements are more frequent than wrong characters in both visual and motor series. In the series of nonsense syllables, the reverse was the case. The absolute number of errors is less than in the series of nonsense syllables.

For A. C. E. in the motor series the displacements are more numerous than wrong characters; in the visual series the wrong characters are the more numerous. This accords with the fact that the motor consciousness was very strong in this subject.

For J. P. H. the wrong characters were more numerous in both the visual and motor series and the same was true for both series of nonsense syllables.

For D. H. wrong characters were more numerous than displacements in both motor and visual series.

For E. H. L. wrong characters were more numerous than displacements in both motor and visual series, and the same was true for the two series of nonsense syllables.

For T. C. wrong characters were more numerous than displacements in both motor and visual series.

The total number of errors for subjects having records for both nonsense syllables and manual alphabet series is, in all cases, less in the manual alphabet series, though in the case of E. H. L. the records are not numerically comparable. The smaller number of characters available for the latter series, in part, accounts for this.

There is, in the manual alphabet series, an increase of error in the second half of a series of ten experiments. (One exception to this occurs, T. C. in the visual series.) That this is probably due more to interference than fatigue is shown both by the introspective report of the subject and the record of errors.[1] Positions of the hand which have occurred in previous series were introduced, frequently in the same serial

[1] Cf. Bergström, "Experiments upon Physiological Memory by Means of the Interference of Associations," AMERICAN JOURNAL OF PSYCHOLOGY, V, 1892-93, 356 ff., and VI, 1893-95, 267 ff.

position which they occupied in the original series. Also, if in any case a series was shown and partially learned, but thrown out in consequence of some violation of experimental conditions, the characters of this series showed a tendency to recrudescence throughout the remaining series of the experiment.

The summation table shows for the motor series a percentage of error varying from 10.5% to 22.2% less than in the case of the visual series.

A study of the characters given wrongly was also made, as in the case of the nonsense syllables. All the errors were counted and tables made showing the number of times each letter occurred in place of another.

No quantitative result has been derived from this tabulation, but a careful comparison with the positions of the hand represented by the letters discloses three well-marked groups of errors:

I. Errors arising from similarity, in which the wrong letter bears either a visual or a motor resemblance to the correct letter. In those bearing a visual resemblance, the naming element is probably present to some extent, a classification into open and closed positions of the hand being made. In some cases, this seems to take the form of contrast, a pairing off of letters formed by opposite motions taking place, *e. g.*, q and g. The interchange of b and m, which have no likeness visually, furnishes an example of motor similarity, as may be readily tested by forming the letters with the hand.

II. Those letters which have occurred in the same serial positions in earlier series tend to recur as errors in later series. This class of errors increases in the later members of ten successive series, and the error tends to repeat itself after having once occurred. This was most marked when a series partially learned, or accidentally seen, was thrown out, the letters of such a series persistently intruding themselves into those given later, as if, having failed to find their proper motor discharge, there was an interference with the later mental images.

III. After all errors which can be classified under either of the preceding rubrics are excluded, there is a residual for

which no explanation, save that of chance occurrence, is apparent.

During the experiments with the manual alphabet above recorded, it occurred to the writer that these series might be utilized as a test of the automatic character of the counting in the series of nonsense syllables. The manual alphabet furnished a visual series, in which the naming element was at a minimum, and the motor element introduced through muscles, in which counting could produce no interference. If, then, the difference in error found in the series of nonsense syllables were due to a distraction of attention, the same result should occur in the manual alphabet series.

Five subjects were experimented upon, three of whom were also subjects of the experiments with nonsense syllables. Reference to the tables and to the curves given on page—— show the result. In every case the curve shows a slight but well-marked decrease of error, which may be fairly interpreted as a continuation of the effect of practice. A still more noticeable fact is the smoothing out of the curve. Reference to the tables will show that not only is the variation in the curve from day to day greatly lessened, but the mean variation of the daily record for each series of ten experiments is also reduced, indicating that the counting actually steadied rather than distracted the attention. With three of the subjects, experiment was continued for a few days with a cessation of the counting. One subject shows a decided rise in the error curve, and in all three the variation from the smoothing out of the curve during the counting is marked. From these results the conclusion seems justifiable that the difference found in the two series of experiments with nonsense syllables was due not to a distraction of attention caused by the introduction of a new factor, but to the inhibition of the motor expression.

As a conclusion from the various experiments represented in this study, can it be fairly assumed that out of the memory complex, the motor element has been quantitatively differentiated and its exact influence measured? To the question in this form the answer must be no. The parallel series were made, as nearly as might be for experimental purposes, to

differ only by the one condition of the introduction of a motor element, but the motor element was by no means excluded from the series called visual, but which was, in reality, a complex of visual, auditory and motor images, for though actual muscular movements were absent, the idea of movement was never entirely excluded, as was shown by the report of the methods used by the various subjects. The difference between the series, then, is not to be explained as a difference between a complex of visual, auditory and motor elements, in which the visual element predominates and a similar complex to which the expression of the motor idea is added.

To those who have served as the subjects of the prolonged and tedious series of experiments, I wish to take this opportunity of expressing my hearty thanks, and especially to Dr. Sanford, who has not only served as subject of the experiments throughout the year, but has furnished constant inspiration by his interest and helpful suggestions.

REMOVE

A PRELIMINARY STUDY OF SOME OF THE MOTOR PHENOMENA OF MENTAL EFFORT.

By Ernest H. Lindley,

Fellow in Psychology, Clark University.

These pages represent the result of an examination of data gathered by questionnaire and by direct observation, dealing with some of the motor phenomena of mental effort. Chief attention is devoted to the study of those postures and movements, rich in variety and little understood, namely, "common motor automatisms."

The following cases from the questionnaire reports will furnish a more definite idea of the material studied. "When studying I often find myself playing with pencil, holding it first on one end and then on the other, or twirl watch-chain. Often look steadily at some distant point, and at such times often squint and slightly frown." Another person "when thinking, frowns, moves uneasily on chair and bites finger nails." A third "always scratches head before attempting anything difficult."

It must be noted that the word "automatism" does not here have the more narrow and technical connotation ascribed to it in psychological texts. Here the term is made to include not only some movements initiated from within, but also many set going from without. It comprehends all tricks and peculiarities of movement and posture, whatever their origin, which have become more or less unconscious, and which accompany mental effort. No attempt is made to separate these common automatisms from the so-called normal expressions of mental effort, partly because the line of demarkation seems a vanishing one, and largely because both classes of phenomena must be studied in their relations to each other if either is to be understood. Both belong to a somewhat neglected chapter of psychology, and both sustain highly important relations to fundamental problems. They may not only

throw new light on the nature of attention and its mechanism, but also furnish important data with regard to mental development.

Returns from the Questionnaires.

The materials for this study were from three sources:

1. Most of the data were observations sent in response to a part of President Hall's Syllabus X (series '95). The topic in question reads as follows:

> III. *Effort Automatism.* Describe the unconscious acts that accompany work or fixed attention—as during recitations,—as biting tongue or lips, chewing a stick or nothing, winking and blinking, twisting buttons, handling articles of dress, playing with fingers, swaying, rocking, rising on the toes, standing on the sides of the feet, turning away, fixating a distant point with the eyes, wriggling, writhing, tapping, drumming, scowling, squinting, tics, grimaces, pulling finger to snap the joints, moving the ears, putting finger in the mouth; whistling, singing and dancing at work. What indicates the hardest effort — as the fidgets or habit chorea seen just before great athletic feats — shutting eyes or ears, moving lips; tunes, verses, etc., persistently running in the head? Is the fœtal posture approached? Does fatigue increase or diminish these movements? Order and per cent. of frequency and duration? Should some be encouraged for better work? At what age are they most common? Treatment?

2. A smaller number of replies to a part of question II of the syllabus issued by President Hall and Dr. Lukens, entitled, "The Beginnings of Reading and Writing." The points in question were as follows: Describe (1) accessory, automatic movements of tongue, lips, hands, eyes, head, legs, feet or body, while writing; (2) ditto while reading.[1]

3. Observations made by the writer, with the coöperation of Dr. Hall in the kindergarten and primary grades of the Boston Normal Training School.

The total number of cases reported was 662. This does not represent, however, the number of persons represented, inasmuch as the same individuals were observed at different times, and therefore each separate record constitutes a case.

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[1] Nearly all the data in reply to the above syllabi were gathered under the able direction of Miss Lillie A. Williams, by the members of her classes in psychology, at the State Normal School, Trenton, N. J. The collection of such data is made a special feature of the child-study pursued there, and the very great care with which the work is done is shown by Miss Williams' article, "How to Collect Data for Studies in Genetic Psychology," in the *Pedagogical Seminary*, Vol. III, No. 3. Our returns, therefore, possess high value, and their great importance in this study is gratefully acknowledged.

While it would be of great advantage to know exactly the number of persons reported on, the replies to the questionnaires were often of such a nature as to preclude accurate determination of this point. Of these 662 cases 235 were of children twelve years of age or under. Of the remaining 427 cases, nearly all are under twenty years of age, the ages sixteen to nineteen furnishing more than half of the 427 cases. We have named the group containing all those over twelve adolescent, inasmuch as it includes only twenty-seven adults, nineteen of whom are men and eight women.[1]

Of the total 662 cases, 421 were females, 241 males. Of the 235 children, there were 117 girls and 118 boys. Of adolescents, 304 were females, 125 males.

The grouping of the automatisms has been a point of considerable difficulty. The system chosen is manifestly rough and imperfect, but was determined as far as possible by the nature of the actual returns. It is as follows: —

Head: Held on side, move sideways, move up and down, move with pen, jerky movements, move.

Face: Grin, grimace.

Eyes: Fixed, wink, close, twitch, roll, squint, bulge.

Ears: Move.

Forehead: Wrinkle, frown.

Mouth: Twitch, drop corners, chew, move.

Jaw: Bite, chew, put objects in, clench, move sideways.

Lips: Draw in and out, pucker, move, work, bite, press, twist, suck, chew.

Tongue: Protrude, move sidewise, move in and out, move with pen, bite, chew, roll, in one cheek, suck.

Hands: Play, clasp, clench, rub or scratch, put in pockets, wriggle, pull hairs, etc., twist hair, smooth, put objects in, move.

Fingers: Play, drum, mark on paper, move up and down, point, move, snap or pull.

Arms: Fold and unfold, jerky movements.

Body: Sway, twist, shrug shoulders, fidget, rock, turn away, move.

Legs: Cross, move, move knees, twist, raise heel, twist heel.

Feet: Sides of feet, stand on one foot, right on left, left on right, rise on toes, rock, lift one foot, move, stamp, wriggle, cross, tap, shake.

The movements and postures are thus distributed among

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[1] This inclusion, as adolescent, of women over twenty-one and of men over twenty-five, is open to criticism, but the numbers are very small, and make practically no difference in the results.

ninety-two classes. Forty-five of these represent the region of the head, twenty the feet and legs, nineteen the hands and fingers. This latter number does not show adequately the relatively great variety in movements of hands and fingers, inasmuch as the classification here was more general.

The following table is designed to exhibit the distribution of automatisms among the different parts of the body, as well as to show the order of frequency of automatisms in children as compared with adolescents.[1] In the last column of the table appears the order in which the automatisms of children preponderate over similar ones of adolescents. The last five items are followed by the minus sign, to indicate that in these classes the automatisms of children are less frequent than in adolescents. In all the others, as indicated by the plus sign, the children show the largest number, those of the head having greatest advantage, mouth next, and so on. This is important as roughly indicating the shiftings of the locality of the automatisms due to age. The numbers with which all the tables deal are manifestly too small to render the ratios anything more than suggestive. The difficulty of observing all the expressive movements of an individual at any given time, is very great, and when we reflect that a large number of cases reported are results of self-observation of these, at best, only semi-conscious movements, it appears highly probable that our totals are too small. Some movements, moreover, such as slight pressure of the lips, contractions of muscles of covered parts of the body, and the like, elude observation more easily than the larger muscular contractions. This source of error tends to narrow the variety of automatisms. Both the above mentioned defects, then, produce underestimation rather than overstatement of the actual phenomena.

In the first part of the table, the numbers opposite each item represent the number of given automatisms in a thousand. In these calculations 1,000 is used as a basis instead of 100 (as in percentage), simply for convenience, in that it yields larger numbers and fewer fractions, without, of course, destroying the original proportion. The method of calculation is as follows. The children, for instance, show thirty-eight body automatisms. This number is divided by 897, the total number of automatisms from all sources, and the result is multiplied by ten, yielding forty-two, which represents the number of cases of body automatisms in a thousand autom-

[1] In the discussion of the tables, the word automatisms is used for convenience, to designate expressive movements as well as common motor automatisms.

TABLE I.

Relative Frequence of Automatisms.

	I Ch.	II Ad.	III Ch. (1.81)	IV *A*	Order of frequency in children.	Order of frequency in adolescents.	*A'*
Fingers	81	143	146	102	Fingers	Fingers	Head+
Feet	72	57	130.3	228	Feet	Feet	Mouth+
Lips	71	53	128	241	Lips	Eyes	Legs+
Tongue	57	26	103	396	Tongue	Lips	Tongue+
Head	48	8	86.8	1085	Head	Hands	Face+
Body	42	33	76	230	Body	Jaw	Lips+
Hands	32	49	57.9	118	Hands	Forehead	Body+
Mouth	20	6	36.2	603	Mouth	Body	Feet+
Eyes	15	56	27	48	Eyes	Tongue	Hands+
Jaw	13	49	23.5	47	Jaw	Head	Fingers+
Legs	6	2	10.8	540	Legs	Mouth	Arms—
Forehead	5	34	9.05	26	Forehead	Legs	Eyes—
Face	3	2	5.43	271	Face	Face	Jaw—
Arms	1	2	1.81	90	Arms	Arms	Forehead—
Ears		2			Ears	Ears	Ears—

Explanation of Table. Columns I and II represent children and adolescents respectively, and indicate the number of given automatisms per thousand. In column III, the ratios of I are multiplied by 1.81 in order to render the numbers for children more easily comparable with those of adolescents; there being 1.81 more adolescents than children reported. In IV *A* is expressed in percentages the proportion of children's automatisms to those of adolescents. For instance, in "fingers," children show 146, while adolescents furnished only 143. The 146 of children is 102% of the adolescents, etc. In *A'* these percentages are arranged in order and the *plus* sign indicates preponderance in favor of children; *minus* sign indicates preponderance of given automatisms in adolescents. The remaining columns show the order of frequency of the different automatisms in children and adolescents respectively.

atisms observed. The average number of automatisms per hundred children is 176, of adolescents 110. If, however, we subtract all the cases of "writing" and "reading" automatisms reported at another time, in addition to those observed by the present writer, the average for the children is reduced to 124, while the adolescent average remains 110.

Let us now consider briefly some of the more striking details. About half of the total number of automatisms belong to parts of head and face. Of single groups recorded, however, "fingers" and "feet" lead in both children and adolescents. In the latter "fingers" show a great advantage over the other automatisms. The "feet" automatisms, however, especially in children, include many cases of mere posture rather than of movement, as standing on sides of feet, and the like. The "lips" rank high in both lists. The connection of these muscles with speech as well as with the gustatory mechanisms would lead us to expect high rank in the table. In the order of greatest relative frequency in children as compared with adolescents, those of "head" show a very great predominance, while those of "mouth," "legs" and "tongue" also exhibit considerable advantage. Of the two most prominent groups in each list—those of "fingers" and "feet,"—it seems evident that there is little decline due to age. The growing relative importance of "eyes" and "forehead" is significant. These are considered the intellectual muscles par excellence, and the above figures indicate the gradual settling of expression in the face. The relative prominence of body automatisms is slightly obscured by the large number of head movements and postures, which are introduced by the writing, reading and kindergarten groups. Of these body automatisms, the most frequent is swaying, and nearly all the cases reported are of children. Playing and drumming with fingers are not so frequent with children as among adolescents. This may be due to the fact that children have as yet no very great ability to make the finer movements of fingers.[1] As between boys and girls, the latter lead greatly in swaying the body, and considerably in finger automatisms, while the boys show greater frequency of tongue, feet and hand movements. Some of these facts are perhaps explainable as due to the greater conformity on the part of the girls to social custom, which would tend to gradual suppression of the more marked of such movements. The average number of automatisms per 100 girls is 179, of boys 181. The quantitative differences

[1] "Development of Voluntary Motor Ability," Bryan (AM. J. PSYCH., Vol. V, No. 2), and "Preliminary Study of Motor Ability," Hancock (*Ped. Sem.*, Vol. III, No. 1).

TABLE II.

Classification of Automatisms According to the Activity that they Accompany.

Writing.		Reading.		Reciting.		Public recitation.		Conversation.		Attention; interested.		Studying.		Difficult recollection.		Greatest effort.	
Lips	240	Body	240	Feet	253	Fingers	433	Fingers	421	Feet	196	Fingers	197	Eyes	339	Lips	238
Tongue	220	Head	180	Fingers	190	Body	170	Hands	131	Fingers	175	Hands	120	Hands	190	Hands	195
Head	170	Hands	140	Body	166	Eyes	170	Forehead	105	Hands	163	Jaw	120	Lips	127	Forehead	173
Feet	170	Fingers	140	Eyes	130	Hands	113	Legs	105	Lips	103	Lips	116	Body	84	Eyes	86
Mouth	87	Feet	110	Hands	120	Feet	56	Eyes	78	Eyes	93	Eyes	73	Head	63	Jaw	65
Forehead	24	Lips	55	Jaw	47	Head	18	Jaw	78	Forehead	92	Feet	67	Forehead	63	Fingers	65
Body	24	Tongue	36	Forehead	23	Jaw	18	Body	52	Jaw	91	Tongue	64	Fingers	63	Feet	43
Legs	24	Arms	18	Lips	23	Lips	18	Head	26	Legs	21	Body	55	Feet	63	Tongue	43
Jaw	14	Jaw	18	Head	15					Body	21	Forehead	43	Jaw	60		
Hand	4			Face	15					Head	10	Legs	30	Face	21		
Fingers	4			Arms	15					Ears	10	Face	12	Mouth	21		
												Head	8	Tongue	21		
												Arms	8				
												Ears	4				
Number of cases.	96		28		109		44		28		47		170		29		30
Average per hundred.	214		180		110		120		100		136		130		160		150

The columns read vertically exhibit the order of frequency of the different automatisms, the numbers opposite the items representing the ratio of the frequency of the given automatism on a basis of one thousand.

due to sex are thus so slight that they are disregarded in further treatment of results.

In order to determine the effect of various kinds of activity and of posture resulting therefrom, the following groups were made, namely, automatisms of Writing, Reading, Recitation, Public Recitation, Conversation, Attention, Study, Difficult Recollection, and Greatest Effort. Such classification, especially in the last five groups mentioned, is obviously more or less arbitrary, but such lines of cleavage seemed to exist in the reports.

Without entering into all the details of Table II, certain general conclusions seemed justified by it.

1. The automatisms tend to vary with the nature of the activity in question. Contraction of certain muscles tends to predominate in writing, while others are most frequent in recitation, etc. In writing, lips and tongue furnish 46% of all the automatisms; in reading, body, head, hands and fingers comprise more than half the whole number; in recitation, feet, fingers, and body lead; in study, fingers, eyes, hands and jaws are most prominent; and so on. This variation is partly due to the manner of accomplishing the task in hand. There will be few automatisms of those muscles directly involved in a given task. Thus in writing, the hand shows few automatisms; in reading, the mouth, lips, tongue and eyes, very few. Another factor in differentiating the automatisms is posture. Those activities which involve standing would show, if everything else were equal, a slight difference in distribution of automatisms from those in which a sitting posture is taken. Swaying of body seldom appears when the subject is sitting, while of course standing on one foot or on the sides of feet, and the like, must depend on a standing position of the body. Again, when those parts which in the general table show greatest frequency of automatisms are pressed into actual performance of work—as the fingers in writing and vocal organs in reading,—the number of automatisms is not thereby apparently diminished. The wave of diffusion simply floods into the most susceptible of the paths remaining free.

A further point, of some significance, remains to be noted. The average number of automatisms per hundred persons appears to increase slightly with intensity of the effort. We exclude reading and writing data, which were collected under different circumstances, and are thus not strictly comparable with the other categories. Recitation, public recitation and conversation show an average of 120 automatisms per hundred persons. Attention, study, difficult recollection and greatest effort yield 136. The numbers dealt with are too

small to give very high value to the averages, but the result raises the important question: Does increase of effort increase the number of automatisms?

Observations in Boston Normal Training School.

It seemed desirable to attempt a more exact determination of the automatisms of young children; the following tests were therefore made in the kindergarten and primary grades of the Boston Normal Training School.[1]

The first series of observations was conducted in the kindergarten. On paper ruled so as to furnish alternate groups of lines, 4 mm. apart and 2.8 cm. respectively, the children were set to drawing lines, zig-zag or vertical, using top and bottom lines as boundaries. They were first to draw large lines for a certain time, then after a short period of rest, small lines for about the same length of time. The order of large and small movements was of course varied, small coming first about as often as large.

The children were arranged in successive groups of six or eight, and those of about the same age were placed in the same group. They were seated at the kindergarten benches, ample room being given, and were asked to "make soldiers" (straight lines), etc. They were urged to do the best work possible. The first group consisted of eight children, four girls and four boys, aged as follows: four girls, six years; two boys, six years; two boys, five years. They were allowed in the first instance to work at the large movements for about fifteen minutes, the time being lengthened in order to see what were the effects of fatigue. After a rest of about five minutes, the small movements were made for about ten minutes. This group showed from the first the most marked automatisms of any of the children tested. The second group (six children—four girls, two boys; girls three and one-half years, boys four) worked at large movements for ten minutes; then, after the usual period of rest, they made small movements for ten minutes. The number of automatisms was much less than in the preceding group. This may be partly due, however, to the fact that these younger children put forth less effort. The intermittence of their work tends to corroborate this view. The third group (eight children–four girls, four boys; girls five years; two boys five; one boy four

[1] For the opportunity of making these tests the writer is indebted to the courtesy of the Boston School Board. The facility of taking them was greatly increased by the kindness of Miss Aborn, in charge of the kindergarten.

and one-half years, the other four years) executed small movements for ten minutes, and then took large movements for the same length of time. The fourth group (seven children—four girls, three boys; three girls five years, one girl four; two boys four, one five years) executed large movements ten minutes, and followed with small movements for same length of time. In the primary grade the same general conditions were observed as above, but the time was lengthened and a large number of pupils participated. Ages of pupils six to seven years. The automatisms were strikingly less energetic and less frequent than in the kindergarten, many of the pupils showing no marked automatisms of any description.

The following is a summary of the observations made:

FIRST SET.

A. Large movements, fifteen min. M.[1] Left foot on side, lips pressed and moved slightly. M. Left foot on right one and twisting of left foot. Right foot on side. Lips pressed and moved with pencil. F. Head down, lower lip to one side, tongue slightly protruded or in one cheek. F. Left foot on right, lower lip moved slightly, knees moved. M. Right foot on left, shifting of feet. F. Head down, lips protrude, mouth moves with pencil. M. Right foot on left, left foot on side. F. Mouth open, head moved.

B. Small movements, seven min. M. Right foot on side. M. Lips move. F. Tongue moved in cheek. F. Legs crossed, lips moved slightly. M. Head on left side, later on left arm. M. Left foot on side, right foot on left, bent over his work, lips pursed. F. Right foot on left, tapping with right toe.

SECOND SET.

A. Large movements, ten min. F. Mouth open, tongue in cheek. M. Tongue out. F. Head down, lips strongly pursed, changed style and position often; pencil in fist, head on left arm. M. Tongue in cheek. F. Lips protruding. M. Scowl.

B. Small movements, ten min. F. Feet back and on sides. Head moved, lips pursed, then ajar, or twitching slightly. M. Left foot on right, lips open, or twitching slightly with movements of pencil. Tongue out. F. Right foot on left. F. Used both hands, then held pencil in fist. Head moved up and down with stroke of pencil. M. Left foot on right. Tongue in left cheek, then moved to other cheek. M. Lips set. F. Right foot on left, lips set. M. Frown, lips set, mouth moved slightly, left foot on right.

THIRD SET.

A. Large movements, ten min. F. Head down, almost to paper, tongue out, left foot on right. F. Mouth twitched slightly. M. Lips set, compressed more tightly in a rhythmical manner. Changed hands. F. Head down, left foot on right. F. Lips pursed, chin puckered, head on left side; theatrical, self-conscious. M. Tongue out, left foot on right. M. Frown, head close to paper, left foot on right.

[1] F. and M. are abbreviations for "female" and "male" respectively.

B. Small movements, ten min. F. Lips pressed, move with pencil, head lower than above, shook his hand in imitation of the third boy. F. Head down, lips move while pressed. Later shook her hand, seemed tired, and lips moved more. At close of time stretched. M. Tired, shook his hand and said he was tired; head lower. F. Head lower, left foot still on right at times. F. Same as above, except somewhat more marked; head lower. M. Tongue out, position about same as in former test. M. Frowned more strongly, head lower, left foot on right; stretched at close.

FOURTH SET.

A. Large movements, ten min. M. Left foot on right, lips pursed, mouth open and moved slightly. M. Tongue partly out, lips and tongue moved slightly. F. Writing with crossed hands, left-handed. Right foot on left. F. Right foot on left.

B. Small movements, ten minutes. M. Moved mouth slightly. M. Best worker, moved mouth slightly. F. Upper lip drawn in, tongue out little way. F. Changed hands toward end; talkative. F. Changed to left hand.

PRIMARY SET.

A. Large movements. M. 6. Head on left arm, lips set, but moved slightly. Head rotates. M. Head very low. F. 6. Head very low. F. Lips pressed and moved. F. 6. Head low, lips pressed. Head on side, tongue slightly protruded. Three F.'s with right foot on left.

B. Small movements. M. 6. Lips move more than when making large strokes; head lower and on one side. F. 6. Head at first inclined backward, then lower, right foot on left. F. 6. Tongue out slightly; body swayed to and fro.

The following general statements seem warranted by the above observations :—

1. The automatisms increase in number and intensity with age in the kindergarten groups, the class containing those of ages three and one-half to four years showing fewest and feeblest. The pupils in the primary grade, however, showed a great falling off in frequency and intensity of automatisms. This latter result is to be expected, inasmuch as the task was relatively easy for children of six or seven years. But the increase of automatisms in kindergarten with age is difficult to understand. Of course the number of cases observed is too small for statistical treatment, but the differences apparently due to age were certainly striking in the cases observed, and suggest the need of more extended observation and experiment. The youngest children seemed little capable of any considerable sustained effort, and in this fact may lie, as has been suggested, the explanation of the small number of their automatisms. Their automatisms were chiefly those of posture.

2. The automatisms were more pronounced in the making of small movements. In many cases the head was brought lower, the body assumed a more collapsed position, the lips

were either pressed more tightly or moved more perceptibly, and other movements were intensified. This suggests the very much greater difficulty of fine work for the child.

3. A majority of the pupils showed marked symptoms of fatigue before the close of the ten minute periods of work. Some shook the hand that held the pencil, others changed the pencil to the other hand. Holding the pencil in the fist, sighing, stretching, shifting positions of body, and frequent intermittences in the work were also noted in some cases; several also said they were tired. In nearly every case the automatisms showed a somewhat rapid increase toward the end of the work period. The surprisingly short time which a young child can work with sustained attention, suggests the need of more scientific determination of the proper period of effort than has yet appeared. The very great fatigue produced by the small movements of hand and fingers, emphasizes what has already been noticed by others, namely, the danger of requiring fine and precise work from young children. *Automatisms are thus a sign of the difficulty of tasks*, and the more intense automatisms exhibited by the children simply show that the given task demanded a degree of skill which they were not yet prepared to acquire. Further tests also in the lower grades of the elementary school might aid in determining at what age writing and other school subjects should be introduced.

Attention may be called in passing to the very great frequency of automatisms of posture. So many placed the feet on the sides, or the side of one foot on the other leg, or assumed collapsed positions of body while at work, that one can hardly escape the suggestion that here we may have that reversion to fœtal posture, noted by Preyer and others as very frequent in children much younger. This point will be further considered below.

Effect of Fatigue.

In answer to the question, "Does fatigue increase or diminish these automatisms?" the replies were not sufficient in number to be decisive. Thirty answered the question. Of these, twenty-three thought that fatigue always, or at least generally, increases the number or prominence of these movements and postures; four thought they diminished with fatigue, and three answered as follows: F., 21: "When fatigued, do not press teeth so tightly, but either rock or tap foot, or drum with fingers." F., 22: "Nervous fatigue increases movements, otherwise fatigue diminishes movements." F., 18: "Have seen intellectual fatigue increase

wriggling." Although in the state of exhaustion there is certainly a loss of muscular tone and a general inability to put forth more than a minimum of effort, it seems probable that in lesser degrees of fatigue there is an increasing restlessness and a distinct rise in the number of the common automatisms as the individual continues at his task. Galton[1] writes, "Restlessness appears to be the commonest sign of partial fatigue." The store of energy is waning and every resource of the mechanism of attention is taxed to call out the whole store of power. The rapid increase in the feeling of effort as fatigue comes on, must in part be due to the increased tension of the muscles in this attempt to arouse all the energy possible. In general, fatigue tends to affect the higher centres first. Inhibition is thus decreased and the motor centres tend at the least stimulation to break out in more or less random movements. Galton mentions the following movements observed during fatigue: sudden muscular movements, grimaces, frowning or compression of lips, twitching of fingers, face, twitching and blinking of eyes, fluttering of eyelids, tendency to nervous laughter or movements. The general unsteadiness of muscular coördination is shown by bad and shaky handwriting.[2]

On the whole, therefore, in view of the diminution of the store of energy and the decline of inhibition, we may expect, in many cases at least, an increase in the number, but a gradual diminution in the intensity of the automatisms when effort is continued during fatigue.

Conclusions. The returns would seem to justify the following general statements:

1. Automatisms of accessory muscles are most frequent. Muscles of the face and head and the fingers and feet furnish a large majority of the total number.

2. Automatisms of the fundamental muscles (body, legs, arms) disappear rapidly with age.

3. In general, automatisms decline in frequency with age. But an increase with age is marked in the frequency of certain specialized contractions, and indicates the gradual settling of expression in the face. The movements of eye, brow and jaw show greatest increase with age.

4. Automatisms show greater individual variation than do the specialized contractions which they accompany.

5. Sex has little influence upon the relative frequency of automatisms.

6. Automatisms vary with the nature of the work and the general posture of the body.

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[1] "Mental Fatigue," *Journal Anthropolog. Inst.*, XVIII, 2.
[2] Galton, *ibid.*

7. Automatisms tend to increase in number with fatigue.
8. They increase in intensity and often in number, with increase in effort.

General Considerations.

The present section is devoted to an attempt to classify and interpret the motor phenomena of effort. As a brief résumé of the data to be explained, the following synoptic table of the expressions of thought, taken from Mantegazza's *Physionomie*,[1] is transcribed: —

"1. *Contractions and relaxations of the muscles of the face.* Contraction of brow muscles, immobility of the eyes, erratic contractions of all the ocular muscles, immobility of all the muscles of the face, exaggerated opening of the eyes, closing or semi-closing of eyes, depression of lower jaw, extreme elevation of one brow, partial or total convulsions of the facial muscles.

"2. *Contractions of the trunk.* Immobility of the whole trunk, catalepsy, partial or total convulsions.

"3. *Sympathetic movements and the more frequent rhythms of members.* Scratching of head, forehead or nose, feeling or touching the head, tapping the forehead or taking the head in one or both hands, caressing cheek or chin, rubbing eyes vigorously, shaking the head, making rhythmical gestures with arms or hands, making rhythmical noise with feet or hands, moving legs incessantly and rhythmically, closing the ears with the two hands."

These movements and attitudes seem to belong to three types:

1. Those which represent specialized contractions; as adjustment of sense organs and the other concomitant changes in the so-called "muscles of expression." These are chiefly facial muscles.

2. Those movements and attitudes which seem to be the result of the general excitement of the nervous system; as swaying of body, tapping with fingers or feet, and the like.

3. Certain postures, which may be the joint result of the withdrawal of the supervision of consciousness, and of the contractions which result from the general nervous excitement.

It is assumed that all mental effort is voluntary attention. This form of attention, we are told, is derived from spontaneous or natural attention, and is in the main a product of civilization, having developed out of the necessity for work.

[1] Mantegazza, 2d edition. Paris, 1889, p. 171.

A brief discussion of some of its phases, and especially of its mechanism, will reveal the basis of the foregoing classification of effort expressions.

In the first place a comparatively low intensity of general awareness is the condition of consciousness in repose. To replace this with a high degree of special alertness, involves the repression of irrelevant sensations and ideas and the emphasis of the relevant ones. So difficult is the attainment of this state of attention that "it drains for its own use, at least in the proportion possible, the entire cerebral activity."[1] Not only do the vaso-motor changes, producing local hyperæmia of the brain, show this concentration of effort, but also the movements and changed attitudes of the body indicate such focalization. In that original and typical form, known as spontaneous sensorial attention, as when a child is captivated by a brightly colored object, the whole body converges toward the object, all the sense organs seem to have a focus at the same place and all motion is arrested. But the investigations in physiognomy show that these muscular contractions are not of equal value, either in relative energy or for the recognition, by an observer, of the nature of the conscious state. Just as consciousness is focalized, so the motor accompaniment tends to have its centre in the muscles of expression of the face and head. Mantegazza writes: "Intellectual expression groups itself always about the head, which is the seat of thought." Again, "If it is necessary to limit to the least space the field of the expression of thought, I include it in the space of some square centimetres which extends below the eyebrows and between them."[2] Piderit accounts for the face as the chief seat of expression partly on the ground that in the face the muscles lie stretched close upon the bones, so that the smallest trembling of a muscle is perceptible to the eye. Furthermore, the roots of the facial nerve arise in the brain in the immediate neighborhood of the "soul's organ," thus rendering spread of nerve currents to this tract especially easy. Lastly, the muscles of the face support the sense organs.[3] Chas. Bell held that the facial muscles assume their important rôle in expression because they are accessory to the muscles of respiration. Both facial and respiratory muscles are controlled by nerves whose nuclei are contiguous, and both assist in communication through their relation to vocal expression. It is here, therefore, that we should expect to

[1] Cf. "Psychology of Attention," Ribot. Chicago, 1894, page 4.
[2] Mantegazza, *op. cit.*, p. 173.
[3] Piderit, "Mimik und Physiognomik," p. 33, 2d ed. Detmold, 1886.

find the most characteristic motor accompaniments of mental effort.[1]

1. *Specialized Contractions.* As the phenomena of "normal expression" are to be considered here only in so far as they contribute to our knowledge of "common automatism," nothing more than a very general sketch of the outcome of the studies in this field is attempted. For more detailed account of the principles of expression, the reader is referred to the works of Darwin, Duchenne, Piderit, Mantegazza and others. One of the pioneers in the scientific study of "specialized contractions" was Duchenne, who considered that he had proved, by electrical stimulation of separate muscles, that a single muscle might be sufficient to the expression of thought or emotion. He called the *occipito-frontalis* (the muscle which lifts the brows) the muscle of attention, the *orbicularis superior* of the eye-lids the muscle of reflection. Darwin, whose great work[2] still remains perhaps the most important in this field, attempted to explain the origin of the association of certain expressions with certain mental or emotional states. Wundt, Piderit, Mantegazza and others have also attacked the problem of the origin of these expressions. Without discussing in detail the various principles invoked by these authors, suffice it to say that all agree that no muscles exist, as Duchenne and other earlier writers thought, simply for the purpose of expression. All now make large use of the idea that expressive movements are more or less weakened repetitions of movements that were once of utility, and becoming closely associated with certain mental states, tend to reappear when these states reappear. Darwin held that the raising of eyebrows in outward attention aids in opening the eyes for better vision. Opening of the mouth aids in intense listening and in the rapid catching of the breath which precedes muscular effort. This opening of the mouth tends to reappear in states of astonishment. The contraction of the muscles around the eyes, of which the primitive use, according to Darwin and Donders, is to protect these organs from being too much gorged with blood during the screaming fits of infancy, survives in adult life in the frown, which comes when anything displeasing presents itself either to thought or action. Mere effort of attention or reflection is displeasing, and thus the *corrugator supercilii* has been called by Duchenne the muscle of thought. The frown, says Darwin, is further developed by need of primitive man for best vision in search of prey or dis-

[1] "Anatomy of Expression," Charles Bell.
[2] "Expression of the Emotions."

tant enemies. Being bareheaded, the brows were contracted to shut out excess of light. Gratiolet calls attention to other useful movements that become associated with continual use of eyes, as closing of eyes and turning away of face when an unpleasant proposition is made,—a survival from disliking to see something unwelcome. In difficult recollection the eyes wander about as if trying to see that which is desired. Wundt, by his principle of reacting similarly to similar feelings, explains many of our expressions by reference to their analogy to "taste," etc. Many experiences are "bitter" or "sweet," and our behavior is the same that it would be if we actually experienced such tastes. Piderit also emphasizes the frequency of our responses to the fundamental senses. Preyer has explained the opening of the mouth in attention, and the protrusion of the lips, by reference to the fact that the first attention of all animals is directed to the search for food. "All examination of and all testing of food is attended by a predominant activity of the mouth and its adjuncts. Especially in sucking, which first awakens the attention of the newly-born, is the mouth protruded."[1] This often remains for years, and appears when attention is strained, especially in such activities as writing, drawing, and the like. Wundt and Piderit have also called attention to the fact that we tend to act as if the object of our emotion or thought were present to us. By intense attention the gaze is fixed on the object, also when the object of our attentive thought is not present, the gaze tends to become fixed. If we frown, we feel something in the eyes that reminds us indefinitely of a blinding light. Mantegazza regards the frown as due merely to sympathy through the contiguity of the nerve-centres of eye and brow.

Many writers have noted the firm closing of the lips during certain activities, and Darwin thought it was perhaps to prevent the respiratory movements interfering with the fine adjustments necessary, for instance, in threading a needle. Gratiolet considered it, since it appeared in effort, as a part of the action of deep respiration, which has for its purpose the retarding of circulation. Mantegazza also considers it as incidental to the deep inspirations which precede effort. Finally, a principle of antithesis is brought forward by Darwin, to account for a few phenomena of expression, as shrugging of shoulders. This principle is essentially that if a certain stimulus prompts a certain set of movements, then a contrary stimulus will prompt the contrary movements.

[1] "The Senses and the Will," p. 303.

Although many of these suggestions seem plausible, the main impression produced by the literature of the subject is that we have only begun to realize the scope of the phenomena involved, and we can only hope for adequate treatment of "expression" when heredity in all its length and depth has been explored. A further conclusion is that the line between so-called movements of normal expression and the common automatisms is a vanishing one, and perhaps in the light of a larger survey of facts it may be shifted so as to include many, if not all, of the latter class.

2. *The Automatisms of the Second Group* are very numerous, and so great are the difficulties of explanation that only the most tentative classification is offered. In general these phenomena are products of the general nervous excitement which appears in mental effort. The following divisions may be made: —

A. Those movements which are simply the result of "diffusion." They include:

a. Movements due to defective inhibition; as twitching of eyes and fingers, squinting, and most cases of "nervous" movements.

b. Movements due to sympathy and imitation, as moving of jaws in unison with scissors, moving of head, tongue and lips with the rhythm of movements of the pen.

B. Those movements, whatever their origin, which help to maintain a sufficient excitement of the brain.

C. Those which serve as a "short-circuit" for such slight nerve currents as otherwise might reach the cortex and dissipate the concentration of consciousness present in mental effort.

These classes overlap to a very great extent, and the above classification is rather a statement of different points of view from which many of the same phenomena may be considered.

There can be no doubt that the effort of voluntary attention increases the activity of the central nervous system. The struggle for the focalization of consciousness, with the concomitant contractions of the muscles of the face and head, must unlock much energy hitherto latent. Again to quote Ribot: "A man worn out by a long walk, by great mental exertion, or who succumbs to sleep at the end of the day's task; a person recovering from a severe illness; — in a word, all debilitated individuals are incapable of attention, because like every other form of work it requires a reserve capital that may be expended. In passing from the state of distraction to the state of attention, there is accordingly a transformation of potential into kinetic energy." How much of

this increased activity is due to the reserve store already in the nerve cells, and how much is produced by the increased charging of the cells by the immediate augmentation of the flow of blood to the encephalon, cannot be determined. Whether the initial stimulus to this arousal of the brain comes from within, in the form of a spontaneous idea, or from without in the form of a sensation, the impressions which flood back from the muscles of expression (including the visceral and other involuntary muscles) may have an important function in further increasing the cerebral activity. The state of attention can be preserved, then, only in proportion as the supply of excitation is adequate. Thus the beating of the head, rubbing of the face, and the like, which by stimulating parts near the brain would be especially efficacious in keeping up the cerebral activity.

A further evidence of the excitement of the central nervous system is furnished by the general tendency to immobility of the body. This quiescence is manifestly not due to a relaxation, but to a contraction of opposing muscles, and consequently represents a considerable expenditure of energy. This excitement, if not under control, overflows and dissipates itself in more or less random movements. At best, voluntary attention is rarely sustained for any great length of time, and seldom is the bodily convergence complete. If the act of voluntarily giving one's-self to the consideration of a task is to be in any degree successful, there must be a considerable intensity of acquired interest and a high development of inhibitory power. The development of this control of mind and body is a slow and toilsome growth, and a brief discussion of its unfolding is of importance for our purpose.

The question of control is, in part at least, the problem of inhibition. The central nervous system has a regulated tone. It is a hierarchy of centres. Each centre tends to constrain and direct the movements of those below, and is in turn more or less controlled by those above. To mention a single illustration,—it is a well-known fact that the reflexes of a brainless frog are greater than those of the normal animal. All authorities agree that the highest control, expressed in such activities as are designated by the terms deliberation, choice, and will, are bound up with the integrity of the higher cerebral centres. Any defect of these centres results in disturbance of the normal activities of the organism, and may lead to grave motor derangement. Pathology presents a vast array of such defects. The prodigal activity of mania, the twitchings and automatisms of late stages of certain febrile disorders, many abnormal postures, and facial expressions of

victims of nervous disease, illustrate this deficiency of controlling power.[1]

In the normal infant, moreover, the higher cortical centres are as yet only slightly developed, and in consequence inhibition lags behind. The lower nerve centres, well nourished and inadequately connected with the higher centres, are discharging constantly into all the muscles, producing that restlessness which has been denominated the very essence of childhood.

The order of development of the nerve centres, then, is from the lower to the higher; from those which mediate coarse adjustments to those which subserve the finer and higher activities. Thus the centres for the body, those of trunk, neck, arms and legs, the so-called fundamental muscles, ripen much earlier than those of the vocal organs, fingers, toes, and the like, which are denominated the accessory muscles or organs. We find here, therefore, an explanation of the greater frequency of the common automatisms of the accessory organs. They elude control longer, and in the lives of most of us never yield implicit obedience.

Chorea, a typical disease of the growth period, shows many of the phenomena of infirmity of control writ large. It has been defined by Sturges as an "exaggerated fidgetiness." Its favorite age is from six to fourteen years. The parts of the body become subject to chorea in the order of the use as intelligent instruments. Untaught muscles and such as have never been employed as the agents of intelligence never suffer chorea. Arms suffer more than legs, fingers more than arms, and the face (among older children) most of all. "Chorea indicates the withdrawal or infirmity of controlling power."[2] Says Clouston, "I think it may be taken as a rule, with few exceptions, that the tissues, the organs and the functions which are of slow development are those which hereditary evil tendencies are most apt to influence."[3] The motor processes are not fully developed until the close of the period of adolescence. This tardiness of growth affords most favorable conditions for the development of inherited motor defect or the fixing of acquired peculiarities of posture and movement. The stress of environment is often too great for these unripe and unstable centres. The pressure of modern life, with its demands for a multitude of fine and precise ad-

[1] Cf. Bancroft, "Automatic Muscular Movements of Insane." AM. J. PSYCH., III, 4.

[2] Cf. Sturges, "Chorea," London, 1881; Sachs, "Nervous Diseases of Children," London, 1895; Donkin, "Diseases of Childhood," London, 1893; Clouston, "Neuroses of Development," London, 1891.

[3] Clouston, "Neuroses of Development," p. 7.

justments, is severest of all upon the accessory muscles, just those whose centres develop so late, and are consequently, in the child, least under control. Conventionality and social custom tend to repress the expression of feeling or thought. This operates to check the nervous exaltation and the intense expression of the young. The school demands bodily stillness, which requires a degree of self-control found only in the best trained adults. Because these conditions interfere more or less with the normal growth of the child, they tend to render inhibition permanently defective.

The natural imitativeness of childhood also contributes to the acquisition of new, or the confirming of old evil motor tendencies. The child sees a movement which he consciously or unconsciously repeats. The habit is quickly formed, and if it supplies an outlet for his energy, soon becomes unconscious, and thus so difficult of repression that it may survive for life.

These three factors, therefore—the enormous activity of the child, the inability to completely control his movements, and the proneness to imitation,—furnish the rich soil out of which spring many of the common automatisms.

The development of inhibition is clearly seen in the gradual disappearance of automatisms of the fundamental muscles, and later of the movements of the accessory muscles which might distract attention. It seems highly probable that most of the automatisms of a normal individual that survive, do so because they actually serve attention in ways soon to be considered. In the children, the automatisms of the head (neck muscles), body, legs and arms constitute 9.7 % of the total number reported, while the same movements and postures reported of adolescents are only 4.4 % of the total, showing a decrease with age of more than one-half. The returns do not show clearly the relative number of extravagant movements, such as indicate incipient nervous disorder.

A.—Automatisms due to Sympathy and Imitation. A child learning to write moves not only the writing hand, but also head, lips, tongue, and, in one case reported, the corresponding forefinger of the other hand. This illustrates the general fact that in acquiring any skill, the first movements employ more muscles than are later needed. Schneider's [1] simile states the case, "Imagine the nervous system to represent a drainage system, inclining on the whole toward certain muscles, but the escape thither somewhat clogged. The streams of water will, on the whole, tend most to fill the drains that go towards these muscles and to wash out the escapes. In

[1] Quoted from James' "Psychology," I, page 113.

case of a sudden flushing, however, the whole system of channels will fill itself and the water overflow everywhere before it escapes." In the child learning any difficult thing, there is this intense flood of energy and no sufficiently definite control of the motor centres involved. The overflow follows the path of least resistance. Hence the centres most affected will be (everything else equal) those most contiguous to the centres from which the diffusion spreads; secondly, those which belong to muscles most frequently employed (usually the smaller muscles); and lastly, those most frequently associated with the activity in question. Those parts of the body which comply with all three of the above conditions, manifestly will exhibit the greatest tendency to movement. Lips and tongue have centres not remote from that of the hand; they are among the most frequently employed muscles, and finally there is evidence, from the facts of aphasia, that in most cases the motor speech centre is probably innervated whenever writing is performed. The movements of the corresponding finger of the other hand may be due to contiguity of the centres in the cord, and to close association of corresponding centres in the cortex. The head movements, intermediated by muscles of the neck, may be partly due also to contiguity. The idea of a rotary movement not only leads to such a movement of the hand, but also of the other mobile parts. Suggestion through the eye of the movement of the writing hand or of the pencil, may reinforce the tendency of the "automatic" movements to assume the same general form.

B.—Excitatory Automatisms. Certain automatisms appear in mental effort, even among the best trained thinkers. An eminent university teacher plays with watch-chain as he becomes most deeply absorbed; a prominent United States senator plays with keys; Lord Derby is said to have always chewed something when making the greatest mental effort, and so the list might be lengthened indefinitely. These automatisms can hardly be explained on the ground of defective inhibition. They are accessory to the mechanism of attention. In order that mental activity may be brought to its maximum, and kept there during a period of work, the circulation of the brain must be rendered adequate, and the latent energy of the nerve cells must be aroused. To aid in accomplishing this, many movements have appeared in the race and in the individual. Their sole *raison d'être* seems to be that they facilitate the work of the brain. Any sort of movement or stimulation may serve, provided it be not so great as to distract the attention. Prominent among the automatisms of the present group are those which are concerned with the stimu-

lation of some part of the face or head. This region is supplied by the tri-facial nerve, and excitation of this nerve seems specially efficacious in arousing the brain. Chewing has been shown to increase the carotid circulation. The use of tobacco, chewing gum, sweets, has been resorted to during periods of great effort of thought. These stimulate the facial nerve. Also the scratching of the head, or stroking of beard or moustache, pressing of forehead, rubbing of eyes, pulling at parts of face, striking the nose, illustrate the value of the stimulation of this nerve. Dr. Lauder Brunton also suggests that there may have been a similar reason for use of snuff. "The general titillation of the mucous membrane of the nose, probably serves to stimulate the cerebral circulation, and the increased arterial tension due to the effects of sneezing, so increases the cerebral nutrition that difficulties seem at once to disappear, and obscurities of mental vision are so rapidly removed that snuff is said in popular language to "clear the head." The above quotation is given for what it is worth, but it does tend to emphasize the very great importance of these stimulations of parts near the brain. Mantegazza distinguishes these movements from those in which the head and scalp are given blows which seem to increase cerebral activity by jarring the brain. If this explanation is true, he thinks it explains why some persons cannot think at their best except when in a carriage, on horseback, or in a boat. Besides the movements which stimulate the face and head, those of the fingers and feet seem also frequent and important. The "drumming" habits of many when in perplexity or deep thought, the need of walking in other cases, probably belong to this category. Slow rhythmical stroking of the head has an opposite effect, soothing rather than arousing the brain. This seems due to the fact that the organism is "set" for certain rhythmical stimulations, the diffusion of the regular impulses being slow enough to proceed without discharging much stored energy.

All active movements therefore, whether of face, hands, legs or feet, tend to increase the central excitement, and this in turn is the necessary condition of great intensity of attention. Movements too excessive, by distracting attention defeat their own purpose, and therefore tend to fall away in all individuals, excepting of course those in whom control is to a great extent deficient. And with these, any high development of the power of voluntary attention is impossible.

C.—Short Circuit Automatisms. Prof. James[1] has advanced the view that certain automatisms are protective of the state

[1] Cf. James' "Psychology," Vol. I, (pp. 457, 458).

of extreme attention. The activity of these movements, according to him, "drains away nerve currents, which if pent up in the thought centres would very likely make the confusion there more confounded. But may it not also be a means of drafting off all the irrelevant sensations of the moment, and so keeping attention more exclusively concentrated upon its inner task?" That automatisms may often play this rôle seems highly probable. But some automatisms appear before there is any considerable degree of attention to be distracted, and many of these or others continue more or less intermittently throughout the whole effort period. At the beginning they certainly seem excitatory. It would appear probable that these two functions, the excitatory and the protective, supplement each other. Prof. G. E. Müller[1] in discussing the well-known fact that the cessation of an unfelt stimulus may be felt, suggests "that impressions which come to us when the thought centres are preoccupied with other matters may thereby be blocked or inhibited from invading these centres, and may then overflow into lower paths of discharge." Now the automatisms at first aid in increasing the cerebral excitation. Under this favorable condition, or concomitantly with it, the state of attention waxes in intensity. When it reaches its height the blocking or inhibiting process may act to shut out the excitatory currents for the moment. Then the nerve paths of the automatisms become the channel for the drafting off of all currents which are excluded from the brain during attention, because "incidental stimuli tend to discharge through paths that are already discharging rather than through others."[2] Hence the movements tend to be kept up, but now serve a different purpose. Furthermore, attention fluctuates. With waning energy of brain, the wave of intensity of attention begins to fall and thus releases to some degree the inhibitions upon these currents flooding in from the contracting muscles, and thus these impulses again reach the brain, and again increase the excitement; only to be shut out again when attention reaches its maximum—and so on until the store of energy is exhausted or the task completed.

If this conception be true, it serves to explain certain important characteristics of automatisms. It is the experience of the writer, and also of others who have been questioned, that the movements preliminary to effort are often different from those which appear when attention is at its best. Moreover, the movements during effort tend to vary both in form

[1] James, *ibid.*
[2] James, *ibid.*

and intensity. When sitting down to a task the arms may be stretched, or parts of the face and head rubbed, scratched or pulled with considerable energy. Or even sometimes the necessity of walking about the room seems imperative in order that worker may "pull himself together." The stretching and straining which often immediately precede the word "go" in an athletic contest are of the same violent sort. These represent the excitatory phase of the automatisms, and when the attention begins to weaken they often reappear again. On the other hand, when the work is under way and concentration seems at its best, the movements tend to become more intermittent and much less violent, and may appear simply as slight twitchings of parts of face, or drumming with fingers, and the like; which are frequently mere fractions of the former total movement. This would be expected, if the automatisms were at the time serving as short circuits for the more or less incidental currents which must be drafted off. That voluntary attention is a late product, and an incomplete copy of spontaneous attention, is shown by the very fact that it proceeds by such expensive devices as these automatisms. We need not look farther for an explanation of the more rapid fatigue in voluntary attention as compared with spontaneous. Lastly, if further observation and experiment should confirm the view of automatisms above suggested, this point of attack may furnish materials for a revision of the theory of attention.

3. *Automatisms of Posture.* Observation of children writing and at other tasks reveals a series of postures so significant as to demand special consideration. Forward bending of the body, with head very much too low, and perhaps on one side, with feet on sides or the sole of one pressed against the lower part of the other leg, represents fairly the usual posture of children in writing. In "recitation" standing on sides of feet is also very prominent. The whole attitude of the child here, as to a certain extent, also in any mental occupation which strongly claims the attention, is so suggestive of reversion that one can hardly escape the conclusion that we have here a return to fœtal posture, and even perhaps a recrudescence of the bodily attitude of man's more remote ancestors. The forward convergence of the body may, of course, be in part due to desire to bring the eyes nearer the object to which attention is given. Dr. Lauder Brunton[1] claims, furthermore, that forward inclination increases cerebral circulation and thus facilitates mental activity. This may have become automatic in the race, but after making allowance for such factors, there

[1] "On Posture and its Indications," *Lancet*, July, '92.

remains a third alternative, namely, that the general collapse of body is "atavistic." Every one knows how difficult is the preservation of the upright position of the body. It requires even in most adults, some supervision more or less conscious, and represents a great daily expenditure of energy. The general drooping forward of the body in fatigue shows how considerable has been the innervation of the muscles in maintaining erect posture. Preyer says that the ability to maintain a sitting posture appears comparatively late, the time varying with different children from the fourth to the eighth month.[1] We may assume, then, that it represents a difficult acquirement, and early in life demands a considerable conscious direction. There is further evidence that control never becomes entirely automatic even with such facile organs as the eyes. Donders holds that in reverie the eyes do not have axes parallel, but really slightly divergent; he also remarks that when one eye becomes blind it always, sooner or later, deviates outward. Le Conte[2] finds that the axes diverge "when we lose control over the ocular muscles, as in drowsiness, in drunkenness, in sleep, and in death." Such cases show clearly the need of control of the eye, in order that the organ may function properly. And if the eye muscles thus fall out of function when consciousness is at a minimum, as in falling asleep, or when the mind is completely absorbed, we can understand why other muscles released from restraint tend to do likewise. The "reductives," so to speak, that enable the centres of control to keep the body upright, are sensations of sight, and those that flood inward from the muscles involved. Now, when there is a low intensity of consciousness available for this function, as in sleep or in fatigue, or when consciousness is strongly focalized on something else, these cues are not appreciated, and in consequence the body and the limbs tend to relapse into those positions which, on the whole, are most habitual. From the standpoint of philogeny, the most habitual attitude must be the most primitive. That the muscles of these members are not relaxed, but contracted, as a result of the general excitement of effort, does not invalidate the explanation, inasmuch as the contractions would follow the same law of premature habit. It seems a generalization of wide applicability, that in proportion as the control of a part of the body declines, there is a tendency of those parts to lose the latest acquisitions and fall back as far as possible upon the primitive conditions.

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[1] "The Senses and the Will," p. 267.
[2] "Sight," Le Conte, p. 255.

The points of this general discussion are put forward merely as suggestions, or even as speculations. At the same time their value will not be lessened by explicit formulation:

1. Many automatisms represent processes for the production and maintenance of central nervous energy, as well as for the protection of the state of attention. They may therefore be considered as important features of the mechanism of voluntary attention.

2. Other automatisms are the result of defective control, and consequently represent serious leakages of energy.

3. Many of the postures suggest reversion to fœtal postures and also to primitive attitudes.

While the questionnaire replies upon which this study is based, were too few in number to yield quantitative results of great value, the high quality of the returns nevertheless justifies the belief that they develop the salient facts concerning the subject in hand. The method is richly suggestive, and defines many problems which can be approached later by wide, systematic observation and experiment. To illustrate: It seems possible to determine experimentally the order in which the different automatisms in a given case arise and decline; the influence of the degree of effort and of fatigue upon these muscular contractions; and the relative influence upon cerebral circulation of the various automatisms. Pedagogically a knowledge of these automatisms is of immediate practical importance. If our classification is correct, these phenomena must not be indiscriminately dealt with in the child. While some automatisms deserve summary repression, many, because they are the means of developing working power, should not, at least, be discouraged. If still others are results of too great deficiency of control, the demand is for the most careful hygienic, if not medical, treatment. Moreover, the excessive movements which accompany the performance of any difficult school task, may serve as an index for a determination of the age at which these requirements may be safely imposed upon the child. If, for instance, in learning to write, the automatisms do not tend to fall away rapidly with practice, then it may be assumed that the centres and muscles involved are not ripe for such a task, and that the strain of performing it is likely to produce, not skill, but nervous disorder.

The writer wishes to express his very great obligations to President Hall, who directed attention to the problem and who coöperated in the collection of data; also to Dr. E. C. Sanford for many helpful suggestions.

LIGHT INTENSITY AND DEPTH PERCEPTION.

By T. R. Robinson, B. A., Toronto.

In a former article the writer described some experiments in connection with the "paradoxical experiment" of Fechner, made in the psychological laboratory of the University of Toronto, with the purpose of investigating the relation of the light intensities of monocular and binocular vision. It was found that the relation could not be very definitely determined, not only because of the variability of the subjective conditions which largely affect it, but also because it depends in great measure upon the absolute light intensity of the object or objects observed. The results, however, suggested some further inquiries, which have been pursued by a method which the present article is an attempt to describe.

The "paradox" of Fechner consists in the fact that when one eye is partially obscured by a smoked glass or other means, the closing of that eye results in a *brightening* of the common visual field, or of an object in the common visual field; *i. e.*, a decrease of intensity of physical stimulus results in an increase of intensity of sensation.

Aubert, following Fechner, found that at a certain degree of obscuration of the second eye occurred the greatest darkening of the common visual field, and that the admission of less light to that eye had then the same effect as the admission of more light, viz., a brightening of the common visual field. This point of greatest darkening Aubert calls the "minimum point," and above and below it are "conjugate points," where the admission of a small or a large degree of light has the same effect upon the brightness of the total visual field.

My own experiments showed that the paradoxical phenomenon occurs only when most of the light is excluded from the second eye. If, on the other hand, comparatively little light is excluded, on the closing of that eye the whole visual field appears darker. Between these limits there is for every absolute intensity what may be called an "indifference point," or point of inefficiency, at which the light admitted to the

second eye has no effect upon the brightness of the common visual field, or of an object in the common visual field.

Dr. Kirschmann, in a comment upon the writer's experiments and their results, as published in a former number of the JOURNAL, offered two suggestions as furnishing a problem for further investigation: (1) That where the paradoxical phenomenon occurs, it is due to the fact that the physical energy which reaches the retina of the partially obscured eye is less than the energy required for combining the two impressions and localizing them in the third dimension. In that case, part of the energy communicated to the retina of the free eye may be subtracted to aid the other eye in producing the binocular combination; then, on the closing of the other eye, this part of the energy would be set free and the result would be an increase of the light intensity. (2) That the "conjugate points" of Fechner and Aubert may be accounted for by the assumption that where one of the monocular intensities is very low, while the other is comparatively high, the binocular combination does not take place. Thus Aubert found the point of greatest darkening where, the light admitted to the undarkened eye being represented by 1000, 122 parts were admitted to the other eye. If this were the lowest point at which the stereoscopic effect is produced, then below it all the light admitted to the second eye would go to increase the light intensity, and, similarly, above it the additional light would have that effect.

Taking, then, these suggestions in connection with the results of previous investigations as a starting point, the experiments which this article describes had for their object to determine the least amount of light which must be admitted to the second eye to produce the stereoscopic effect, and to find whether or not that amount of light corresponds to the amount which is inefficient as regards the comparative light intensities of monocular and binocular vision. If the first of the above suggestions were correct, we should expect to find that the maximum of light which can be admitted to the partially obscured eye without increasing the total brightness, approximates to the minimum of light required in that eye to produce the stereoscopic effect. If the second suggestion were correct, we should expect that the stereoscopic effect would not appear below the "minimum point" of Fechner and Aubert, *i. e.*, where less than 0.122 of the full light was admitted to the second eye.

The apparatus used is shown in the accompanying plate (Fig. 1). Though simple in appearance when completed, and very easily manipulated, its construction required much care. It was manufactured especially for this research from

a design furnished chiefly by the director of the laboratory, Dr. Kirschmann, to whom also thanks are due for valuable suggestions and assistance throughout the investigation. In front are two stereoscopes, the inner lens of each of which may be closed by means of a small shutter. Behind these is an episkotister disc turned by an electric motor; this disc is graduated in 360° and arranged so as to vary the light admitted between the limits of 0° and 270°. The stereocopes are arranged before the episkotister in such a way that one eye looks at the object directly, the other through the revolving disc. Immediately behind the disc is placed a black velvet screen with two openings on each side, opposite the lenses of the stereoscopes. Behind this again at the focal distance of the stereoscopes, is a second black screen, on which are fixed the objects to be observed. The objects chiefly used were four small squares of white cardboard placed before each stereoscope, with right-lined figures drawn, as in Fig. 2, so that when combined they present the appearance of two pyramids, one above the other, the apex of the upper one projecting towards the observer, that of the lower one receding, and thus presenting the appearance of a hollow passage. By the use of *two* sets of objects and *two* stereoscopes, there were avoided possible errors which might arise (1) from a difference between the two eyes of the observer; (2) from a difference in the treatment of the two eyes throughout the experiments. The purpose of using two pyramids on each side was to afford an indubitable criterion of the binocular combination. This criterion consists in the small squares which form the summit of the pyramids being seen in the middle of the larger squares and vertically one above the other. Such a criterion is necessary, because as the light admitted to one eye is gradually decreased by means of the episkotister, the binocular combination does not at a certain point suddenly cease, but becomes gradually less and less complete, until at length it ceases to be perceptible. It was found necessary to use the simplest outline drawing possible, as photographs, etc., have, even when looked at with one eye, a certain depth effect, dependent, of course, on secondary factors of depth perception, which made discrimination more difficult.

The observer looks alternately through the right and left-hand stereoscopes, and after each double trial[1] readjusts the episkotister so as to admit more or fewer degrees of light, and continues thus till there are found (1) the lowest point

[1] This does not imply a perfectly conscious method, as the observer was unaware of the absolute intensity.

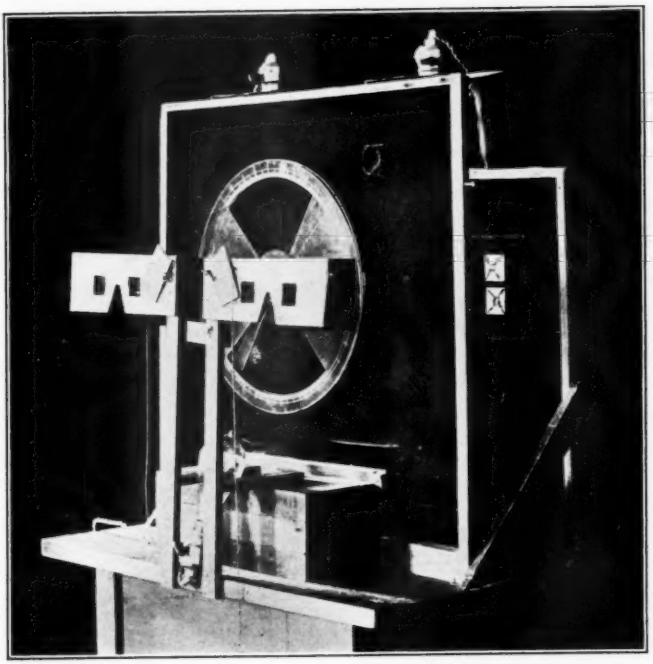


FIG. 1.

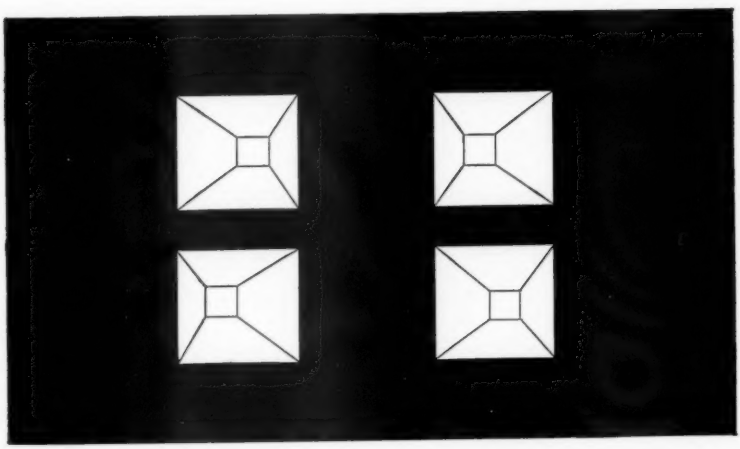


FIG. 2.

at which the objects continue to be completely combined, and (2) the point at which there is no longer any combination at all. The shutter is used to close one lens of the stereoscope so as to compare the monocular and binocular effects. The "indifference point" of light intensity is found, according to the method described fully in the former article, by first looking through the stereoscope at the objects and then excluding one eye by means of the shutter, and after each trialreadjusting the disc until a point is reached where no difference in brightness is observable, whether the object is regarded with one eye or both. The adjustment of the episkotister wasfacilitated by the use of the incandescent lamp, shown in the front of the figure, between the supports of the stereoscopes. This light was turned off during the trials, and when in use screened from the eyes of the observer. The screen used for this purpose, as well as the black velvet covering kept over the apparatus when in use, is not shown in the figure, in order that all parts of the apparatus might be more distinctly visible. Each set of objects was lighted by an electric lamp suspended between the screens, and the intensity was varied by using lamps of different candle power, or by placing sheets of tissue paper around the lamps. All the experiments were conducted in a dark room. Owing to the number of trials required, it was not possible to secure series of trials from many observers, but those obtained had the advantage of being made by persons accustomed to psychological experimenting, the observers, besides the investigator, being Mr. W. B. Lane, M. A., a fellow graduate student, who was conducting some researches in the laboratory; Dr. Kirschmann, and Mr. A. H. Abbott, B. A., assistant in the laboratory. The writer desires to express his indebtedness to the kindness of these gentlemen, especially Mr. Lane, who devoted much time to patient observation. The results of the trials are shown in the following tables.

TABLE I. OBSERVER R.

DESCRIPTION OF LIGHT USED.	PHOTOMETRICALLY DETERMINED INTENSITY OF THE LIGHT.	MINIMUM AMOUNT OF LIGHT NECESSARY FOR THE SECOND EYE IN ORDER TO OBTAIN COMPLETE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE BRIGHTNESS OF THE COMBINED VISUAL FIELD.		
		a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.
8 c. p. lamp + 34 t. p.	1	$147\frac{1}{2}^\circ$	.41	.41	85°	.18	.18	$151\frac{1}{4}^\circ$	.41	.41
8c.p.+26t.p	2.77	85°	.65	.23	$48\frac{1}{2}^\circ$	.37	.13	$157\frac{5}{16}^\circ$	1 21	.43
" 20 "	3.88	65°	.70	.18	$32\frac{1}{2}^\circ$	.35	.09	$156\frac{11}{16}^\circ$	1.68	.43
" 16 "	6.66	$66\frac{3}{4}^\circ$	1.31	.19	$30\frac{1}{2}^\circ$	.55	.08	$174\frac{1}{2}^\circ$	3.23	.48
" 12 "	16.16	$47\frac{1}{2}^\circ$	2.09	.12	14°	.64	.03	$197\frac{3}{16}^\circ$	9.12	.56
" 8 "	29.16	32°	2.59	.08	$10\frac{3}{4}^\circ$	.85	.02	$175\frac{1}{16}^\circ$	14.17	.48
" 4 "	56.94	$19\frac{1}{4}^\circ$	3.04	.05	$5\frac{7}{8}^\circ$	.90	.01	$174\frac{1}{4}^\circ$	27.51	.48
8 c. p.	100.00	$12\frac{1}{2}^\circ$	3.47	.03	$2\frac{3}{4}^\circ$	.74	.007	$145\frac{1}{2}^\circ$	38.20	.38
16 "	192.00	$10\frac{3}{8}^\circ$	5.53	.02	$1\frac{1}{2}^\circ$	.80	.004	$126\frac{29}{32}^\circ$	67.69	.35
32c.p.+4t.p.	527.70	12°	17.59	.03	$\frac{3}{4}^\circ$	1.09	.002	$103\frac{1}{16}^\circ$	145.91	.27
32 c. p.	1,014.80	5°	14.09	.01	$*\frac{5}{12}^\circ(?)$	1.10	.001	$117\frac{21}{32}^\circ$	330.54	.32
50 "	1,515.70	$3\frac{1}{2}^\circ$	14.03	.009	$*\frac{3}{8}^\circ(?)$	2.80	.001	$90\frac{101}{141}^\circ$	381.93	.25
100 "	3,130.40	$5\frac{1}{3}^\circ$	46.37	.01	$*\frac{1}{4}^\circ(?)$	2.17	.0006	$82\frac{7}{8}^\circ$	719.98	.22

*A partial stereoscopic effect sometimes remained at a point lower than the disc was graduated to measure.

TABLE II. OBSERVER L.

DESCRIPTION OF LIGHT USED.	PHOTOMETRICALLY DETERMINED INTENSITY OF LIGHT.	MINIMUM AMOUNT OF LIGHT NECESSARY FOR SECOND EYE IN ORDER TO OBTAIN COMPLETE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE BRIGHTNESS OF THE COMBINED VISUAL FIELD.		
		a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.
8 c. p. lamp + 34 t. p.	1	225°	.62	.62	114°	.31	.31	$229\frac{7}{8}$°	.63	.63
8c.p.+26t.p.	2.77	$176\frac{3}{4}$°	1.35	.48	42°	.32	.11	$169\frac{1}{19}$°	1.26	.45
" 20 "	3.88	102°	1.02	.26	$26\frac{7}{8}$°	.28	.07	$177\frac{5}{8}$°	1.91	.49
" 16 "	6.66	$93\frac{1}{8}$°	1.72	.25	$16\frac{3}{8}$°	.30	.04	$156\frac{3}{4}$°	2.89	.43
" 12 "	16.16	80°	3.59	.22	$9\frac{2}{3}$°	.43	.02	$176\frac{1}{4}$°	7.21	.44
" 8 "	29.16	$34\frac{1}{6}$°	2.76	.09	10°	.83	.02	$173\frac{3}{4}$°	14.07	.48
" 4 "	56.94	$42\frac{1}{2}$°	6.70	.11	$4\frac{5}{8}$°	.67	.01	$186\frac{1}{2}$°	28.52	.50
8 c. p.	100.00	$28\frac{1}{2}$°	7.87	.07	$2\frac{5}{8}$°	.78	.007	190°	52.77	.52
16 "	192.00	$22\frac{1}{2}$°	12.00	.06	$1\frac{5}{8}$°	.89	.004	$146\frac{11}{14}$°	78.28	.40
32c.p.+4t.p.	527.70	5°	7.32	.01	$\frac{1}{3}$°	.73	.001	†$97\frac{1}{4}$°	142.91	.27
32 c. p.	1,014.80	7°	19.73	.01	*$\frac{1}{4}$°(?)	.73	.0007	$190\frac{1}{18}$°	537.75	.52
50 "	1,515.70	$8\frac{7}{8}$°	37.36	.02	*$\frac{1}{5}$°(?)	84	.0005	$156\frac{1}{5}$°	657.50	.43
100 "	3,130.40	$15\frac{3}{4}$°	136.95	.04	*$\frac{7}{8}$°(?)	7.61	.0002	$173\frac{1}{10}$°	1,505.58	.48

*A partial stereoscopic effect sometimes remained at a point lower than the disc was graduated to measure.
†Result of only one series.

TABLE III. OBSERVER K.

DESCRIPTION OF LIGHT USED.	PHOTOMETRICALLY DETERMINED INTENSITY OF LIGHT.	MINIMUM AMOUNT OF LIGHT NECESSARY FOR SECOND EYE IN ORDER TO OBTAIN COMPLETE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE BRIGHTNESS OF THE COMBINED VISUAL FIELD.		
		a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.
8 c. p. lamp + 34 t. p.	1	110°	.30	.30	70°	.19	.19	†Undecided.		
8 c.p.+26t.p.	2.77	63°	.45	.16	47°	.36	.12	$164\frac{1}{2}$°	1.41	.50
" 20 "	3.88	50°	.53	.13	31°	.33	.08	$166\frac{1}{2}$°	1.79	.46
" 16 "	6.66	29°	.55	.08	14°	.25	.03	$180\frac{1}{3}\frac{0}{3}$°	3.33	.50
" 12 "	16.16	23°	1.03	.06	9°	.40	.02	$172\frac{2}{3}$°	7.73	.47
" 8 "	29.16	15°	1.21	.04	3°	.24	.008	$246\frac{0}{3}$°	19.92	.62
" 4 "	56.94	15°	2.37	.04	$3\frac{1}{2}$°	.55	.009	$170\frac{5}{8}$°	27.02	.47
8 c. p.	100.00	11°	3.05	.03	$2\frac{1}{2}$°	.69	.006	$131\frac{2}{3}$°	36.57	.36
16 "	192.00	$11\frac{1}{2}$°	6.13	.03	$\frac{1}{2}$°	.26	.001	$148\frac{1}{2}$°	79.11	.41
32 c.p.+4t.p.	527.70	$2\frac{1}{2}$°	3.66	.006	$\frac{1}{2}$°	.73	.001	135°	197.88	.37
32 c. p.	1,014.80	3°	8.45	.008	*$\frac{1}{4}$°(?)	.70(?)	.0006 (?)	$113\frac{5}{6}$°	320.88	.31
50 "	1,515.70	2°	8.42	.005	*Not found.			$128\frac{1}{2}$°	541.32	.35
100 "	3,130.40	$1\frac{1}{4}$°	10.86	.003	*Not found.			$106\frac{2}{4}\frac{3}{4}$°	926.49	.29

*A partial stereoscopic effect remained at a point lower than the disc was graduated to measure.

†On account of the dimness and orange color of the light coming through so many sheets of tissue paper, the monocular and binocular light intensities could not be discriminated very clearly.

TABLE IV. OBSERVER A.*

DESCRIPTION OF LIGHT USED.	PHOTOMETRICALLY DETERMINED INTENSITY OF LIGHT.	MINIMUM AMOUNT OF LIGHT NECESSARY FOR SECOND EYE IN ORDER TO OBTAIN COMPLETE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE STEREOSCOPIC EFFECT.			AMOUNT OF LIGHT FOR THE SECOND EYE INEFFICIENT FOR THE BRIGHTNESS OF THE COMBINED VISUAL FIELD.		
		a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.	a. In degrees of the Episkotister.	b. In units of intensity.	c. Ratio of the intensity for the other eye.
8 c. p. lamp + 16 t. p.	6.66	112°	2.07	.31	32°	.59	.08	†192⅔° (?)	3.55	.53
8c.p.+12t.p.	16.16	90°	4.04	.25	22½°	1.01	.06	†231⅕° (?)	9.87	.61
" 8 "	29.16	110°	8.91	.30	32½°	2.63	.08	217 7/8°	17.59	.60
" 4 "	56.94	90°	14.23	.24	25°	3.95	.06	187⅛°	29.61	.52
8 c. p.	100.00	22°	6.11	.06	9°	2.50	.02	98⅜°	27.31	.27
16 "	192.00	22°	11.73	.06	9°	4.80	.02	131½°	70.00	.36
32c.p.+4t.p.	527.70	55°	75.06	.14	1°	1.46	.002	115⅚°	243.08	.46
32 c. p.	1014.80	9°	25.37	.02	3°	8.45	.008	108⅜°	306.55	.30
50 "	1515.70	10°	42.10	.02	1½°	6.31	.004	†210° (?)	884.15	.51
100 "	3130.40	50°	434.77	.13	½°	4.34	.001	87½°	761.10	.24

* Owing to special conditions, the trials with this observer were not made with the three lowest intensities.
†The "equal" limits had not been passed at 135° on the disc.

The intensities of the lights used were measured relatively to each other by means of an episkotister photometer; in the table the intensity of the weakest light, that of an eight-candle power electric lamp, surrounded by thirty-four sheets of white tissue paper, is given as 1, and the others in comparison with it. The results of each observer are exhibited in a separate table. The second main division of the tables shows the lowest point for each absolute intensity at which the stereoscopic effect was complete, the third the point at which it had entirely ceased. Between these points there was a region of partial or incomplete combination. Here the objects were sometimes confusedly intermingled; sometimes the complete stereoscopic effect would alternately appear and disappear, and again there would occur the phenomenon of competition of the vision fields, first one and then another set of lines becoming more distinct. The fourth division of the tables gives for each absolute intensity the amount of light which can be admitted to one eye without producing any change in the brightness of the common vision field. It will be observed that in this division the results are less regular than in the others. This is probably because: (1) The judgments concerning light intensity are more difficult than those concerning the stereoscopic effect, and to secure regularity would require the averaging of a greater number of trials; (2) With the lower intensities the tissue papers gave always a certain degree of color which had to be abstracted from in judging of the brightness, as the color would also change on the closing of the shutter; (3) These difficulties gave rise to a third source of irregularity, viz., that the observer had often to look for some time at the object before deciding, and in those cases, owing to the adjustment of the eyes, the results were probably somewhat different from what they would have been could the judgment have been given immediately. The results, however, appear sufficiently exact for the purpose of our comparison.

It is also noticeable that the results are less regular with very high absolute intensities, probably because these intensities are somewhat near to what, for the eye adapted to the low intensities of the darkened room, forms the "upper limit."

We may now attempt to estimate the significance of our results.

I. The amount of light required in the second eye to produce the stereoscopic effect seems with most of the intensities used surprisingly small. With very high intensities one one-hundredth of the full light, or less, was sufficient to make it complete, while a partial effect in many cases re-

mained with the very least amount which the disc could be adjusted to admit. Where episkotister values of less than 1° are given, no great reliance can be placed on their accuracy, as the disc was not graduated to measure smaller quantities than half a degree with exactness. Where such values are given in the tables, they represent the average of different results, in some of which the lowest intensity measurable was not low enough to make the stereoscopic effect disappear. On the other hand, with the lowest absolute intensities, about one-half the full light was necessary for the second eye in order to produce the complete stereoscopic effect, while for any stereoscopic effect at all, from about one-fifth to one-third of the full light was required. In connection with these results two problems are presented: (1) To account for the great difference between the proportion of light required for the second eye at low absolute intensities, and that required at high intensities. (2) To account for the wide range in all cases between the point where the objects begin to combine, and the point where the complete stereoscopic effect is obtained. The amount of light at the latter point is about from two to twenty times as great as at the former.

With regard to the first of these questions, there seems to be something more involved than mere proportionality; for while the amount of light required for the second eye increases regularly with the increase of the absolute intensity, the increase is not *proportionate;* so far from it, indeed, that the ratio of the intensities for the darkened and the undarkened eyes, instead of increasing or remaining constant, decreases so rapidly that it is from fifteen to one hundred times smaller at the highest than at the lowest intensities. This would seem to suggest that the coöperation of the two retinas in producing the binocular combination, is of so intimate a character that where one retina is not stimulated sufficiently to enable it to play its part in that combination, its energy may be supplemented by that of the other. If that be so, then naturally the greater the amount of light admitted to the free eye, the greater will be the energy which can be spared to supplement that of the partially darkened eye, and consequently the smaller the proportion of light required in the latter for the binocular combination. This point will be discussed more fully further on, but it may be noted here that by the *binocular* combination is not meant the *stereoscopic* combination. The factors of binocular depth perception are of course such that in it one eye cannot do any part of the work of the other. But in order to the production of the stereoscopic effect, it is first necessary that the two images should be combined so as to present the appearance

of a single surface; and it is in this combination that the interpretation of our results seems to require the assumption that part of the energy of the retina of the free eye is directed to aiding the other retina. This hypothesis is supported by, and at the same time affords an explanation of, the second fact above noted, viz., that the amount of light admitted to the second eye at the point where the objects begin to combine is only a small fraction of that required for the complete stereoscopic effect. For if in the former case only the coincidence of surfaces takes place, and in that the free eye can aid the other, while in the latter there occurs the complete stereoscopic combination, it is evident that in the latter case the aid which the free eye can render to the other is proportionately much smaller, and consequently the proportion of light required in the second eye much greater than where the objects combine only as in a plane surface. This distinction of the binocular from the complete stereoscopic combination is not a merely hypothetical one, as throughout the course of the experiments it was frequently noted that the objects would coincide as a single surface where there was no depth effect perceptible.[1] In this case the lines did not combine, and, for the observer *L.* especially, one of the criteria for the completeness of the stereoscopic combination was that as soon as it began to be incomplete, he had "double images" of the small central squares.

II. The "indifference point," or point of inefficiency as regards the comparative light intensities of monocular and binocular vision, varies also in correspondence with the absolute intensity; the amount of light which can be admitted to the second eye without affecting the brightness of the common visual field increases regularly with the increase of the absolute intensity. The ratio of the amounts of light admitted to the obscured and the unobscured eyes shows, however, at this "indifference point" less variation than at the lowest point of effectiveness for the stereoscopic combination. In this connection there are three points which seem to require explanation: (1) That so large a proportion of the full light, varying, with different absolute intensities and different observers, from about one-fifth to nearly two-thirds, can be admitted to the second eye without increasing the total brightness; (2) That while the amount of light for the second eye inefficient for the brightness of the combined visual

[1] For the further elucidation of this point, *i. e.*, the possibilities of binocular combination, *vide* the tables appended to Dr. Kirschmann's article on "Metallic Lustre and The Parallaxis of Indirect Vision," *Philos. Studien*, Vol. XI, 1895, pp. 147-189.

field increases in quite regular correspondence with the absolute intensity, the increase here, as with the light required in the second eye for the stereoscopic effect, is not proportional, so that while the actual amount of light increases, the ratio to the full light continuously decreases; (3) The paradoxical phenomenon, viz., that below the "indifference point" the closing of the partially darkened eye causes a brightening of the common visual field, *i. e.*, a decrease of intensity of physical stimulus results in an increase of intensity of light sensation. With regard to the first of these points it is only necessary to recall the fact that the purpose of the two eyes is not to increase the intensity of light sensation, but to localize objects in space. The second and third points are somewhat closely related, and will be dealt with together in the next paragraph.

III. What is the bearing of our conclusions upon the two suggestions which formed the starting point of the investigation?

1. With reference to the suggested explanation of the "paradoxical experiment" of Fechner. If the experiments confirm this suggestion, the explanation of the paradoxical phenomenon will be quite simple: So much of the energy communicated to the retina of the second eye goes to combine the two retinal images and localize in space the combined image, the remainder, subject, of course to the law of Weber, goes to increase the light intensity of the combined visual field; or, where the energy which reaches the second retina is insufficient to produce the stereoscopic effect, part of the energy is subtracted from the other retina to aid in combining the objects, and the result is a darkening of the common visual field. To confirm this suggestion the results should show a practical coincidence of the "indifference point" of light intensity and the lowest point of effectiveness for the stereoscopic effect. Now, on reference to the tables, it will be seen that the "indifference point" is very much higher in nearly all cases than the point below which the stereoscopic effect ceases to be good; the lower the absolute intensity, however, the nearer these points approach each other, and at certain extremely low absolute intensities they practically coincide. This would seem to indicate that the explanation holds good for these low intensities; the question at once arises, "Why not for higher intensities?" This may be explained quite readily on the supposition that at such low intensities as are denoted in the tables by 1 and 2.77, the light which reaches the retina of the unobscured eye is very little more than sufficient to enable that eye to perform its part in the binocular combination. This supposi-

tion is supported by the fact observed throughout the experiments, that with these very low intensities, at the lowest point where the stereoscopic effect was obtained, the outlines of the objects were not clearly visible with the darkened eye alone, while with higher intensities they were visible with the darkened eye below the point where the stereoscopic effect had ceased to appear. Assuming this supposition to be correct, what bearing will it have upon our results? If we take, for example, in Table 1 the absolute intensity 1, we find that the light which must be admitted to the second eye to produce the complete stereoscopic effect is represented by .41, and .41 also represents for the absolute intensity 1 the amount of light for the second eye, which has no effect on the light intensity of the common visual field. If less light than .41 is admitted to the second eye, therefore, we shall have the "paradox," and we shall not have complete, but only partial stereoscopic effect. Why is this? Apparently because the stimulus applied to the second eye in this case is not sufficient to produce the energy required for the stereoscopic effect. Part of the energy appears to be subtracted from the other retina to aid in the binocular combination, and consequently the common visual field is darkened. But because the energy communicated to the free eye is little more than is needed to produce the required effect in it, there cannot, while that eye continues to discharge its function, be sufficient energy withdrawn from it to make up what is lacking in the other eye, and hence the stereoscopic effect remains incomplete. Then taking a higher absolute intensity, say that represented in the table by 100, we find that the amount of light for the second eye required to produce the complete stereoscopic effect is 3.47, while the amount inefficient for the brightness of the combined visual field is 38.20. Now, on our theory it may be held that the energy which reaches the retina of the free eye is in this case more than is required for that eye to play its part in the coöperation of the two eyes, and where the other eye does not receive sufficient for that purpose, enough energy may be subtracted from the free eye to supplement that of the partially obscured eye, and produce the complete stereoscopic effect. This would account for the fact that with all but the lowest intensities, there is a region, growing more extended as the absolute intensity increases, where the paradoxical phenomenon occurs, while yet the stereoscopic effect is completely preserved.

2. With reference to Fechner's and Aubert's "minimum" and "conjugate points," the suggested explanation

was that below the "minimum point," *i. e.*, the point of greatest darkening in the common visual field by the partial obscuration of one eye, there is no binocular combination, so that all the light admitted to the second eye may go to increase the total brightness; while, on the other hand, above that point, the additional light is not needed for the stereoscopic effect, and so may go to increase the light intensity of the combined visual field. This at first seems also to obtain at least a partial support from the results, as at low intensities—in Tables I and II that denoted by 2.77,—the point where the stereoscopic effect ceases to appear, is rather near the "minimum point" of Fechner and Aubert, namely, .122 of the light admitted to the undarkened eye. There does not, however, appear to be in this case any satisfactory explanation of why these points do not coincide as well at higher intensities, so that their practical coincidence at this one intensity may be merely accidental. Moreover, this explanation would require that as the light admitted to the second eye is decreased, the stereoscopic effects continue complete down to a certain point, and below that point entirely disappear. This, as we have seen, is not the case; below the point where the combination ceases to be complete, there is a rather extended region of partial or incomplete combination. The difficulty seems to be that the fixing of the "minimum point" definitely at .122 is itself not to be relied on, for (1) reference to the tables shows that though the ratio to the full light of the light required for the second eye to produce any effect on the total intensity remains within comparatively narrow limits fairly constant, yet on the whole that ratio varies in correspondence with the absolute intensity, and (2) it must be remembered that the "indifference point" is not usually a single definite point, but that there is usually a considerable region within which no difference in the light intensity of an object in the common visual field is observed when the object is regarded alternately with one eye and two, and the figures in the tables represent simply the averages of all the equal cases.

RÉSUMÉ.

I. The amount of light required for the second eye to produce the stereoscopic effect, is, especially with high intensities, very small.

II. The amount required depends on the absolute intensity.

III. There is a considerable range between the lowest

point where the objects combine, and the point where the complete stereoscopic effect is obtained.

IV. The amount of light for the second eye inefficient for the total brightness corresponds to the amount required for the stereoscopic effect only at very low intensities; at higher intensities it is much greater.

V. The results seem to indicate a coöperation of the two retinas of so intimate a character as to afford a ground for the explanation of Fechner's "paradoxical experiment."

VI. The distinction between simple binocular coöperation and complete stereoscopic combination, noted in the course of the experiments, presents a problem for further research.

ATTENTION: EXPERIMENTAL AND CRITICAL.

By Frank Drew.

Late Fellow in Psychology, Clark University.

OUTLINE. I. Some slight additions to the reported experiments on Attention. II. A brief historical sketch of the subject. III. The writer's views. IV. A summary of by-products of the experiments which suggested, and in turn get meaning from, the view held. V. Bibliography.

I.

At the outset there will be no attempt made to define Attention; the word will be used in its ordinary sense. The experiments to be described, and which were performed in the laboratory of Clark University, fall into three general groups. In the first, use was made of perception, association and reaction time; in the second, perception and association; in the third, perception only. In these groups the question set was always: What differences, if any, can be found in the results of a given task performed on one occasion with concentration, at another with distraction of attention?

A. Reaction-Time.

This series, carried on in the winter of 1893-4 and fall of 1894, aimed to combine tasks of various degrees of difficulty with distraction of various degrees of effectiveness. Its object was to arrange a series of tasks of increasing degrees of complexity which should make ever greater demands on the mind, until attention should pass from a fully concentrated to a completely distracted state. The work was begun in full sympathy with Wundt's position, and, indeed, was understood as but a mere continuation of the course begun by him and others.[1] The experiments with five subjects[2] were as follows:

I. Multiplication table up to 12×12, factors given in four sets of eighteen couplets each, in hour sittings, first and last sets with concentrated attention and signals; second and third without signals and with distraction. The distraction consisted of: reading text (1) silently, (2) aloud; naming letters (1) in direct order in text, (2) in reverse order, (3) on drum, seen one at a time; fixation of one letter seen through a slit. Further work was given also in multiplication, *e. g.*, 6×19, etc. The factors were given (1) orally, circuit closed with last factor, (2) by Fall-apparatus. Reading, for purpose of distraction, was (1) stopped when last factor was given, (2) continued until after answer was got. Reactions made by finger key and with mouth key; to be made in shortest possible time.

II. Stimuli—(a) by *Fall-apparat:* (1) letters, (2) colors, (3) diagrams, *e. g.*, crescent, star, circle, triangle, cross, (4) factors to be multiplied, (5) numbers from one to ten; (b) oral: factors and

[1] Phys. Psych., 4th ed., Vol. II. Chap. XVI, and *Mind*, Jan., 1895, p. 79.

[2] Besides the writer these were Dr. E. C. Sanford, Mr. A. H. Yoder, Mr. A. C. Ellis and Mr. J. R. Slonaker. To these gentlemen I am greatly indebted for many months of careful work.

numbers as in (4) and (5). Reactions made on five and ten-fingered keyboards were semi-adaptive, or with from one to all the fingers of one or of both hands. Stimuli were given in four sets: first and last with free attention and ready signal; second and third with distraction and no signal.

The times were taken chiefly by the Hipp chronoscope, though other methods were used. The figures obtained are regarded as unsatisfactory, though in passing it should be said they are in substantial agreement with those obtained by other experimenters working under like conditions. Greater stress is laid on the observations made during the course of the experiments on external and introspective accompaniments; rather full notes kept of these will be given in connection with similar data got while carrying out other lines of experiments.

B. Association Experiments.

Association experiments were performed in spring of 1894, to find in what degree, if any, the process and variety of strictly relevant associations are affected by concentration and distraction of attention. The material consisted of four sets of cards prepared for me, 100 in each, on which were written words, grouped as follows:

	I.	II.	III.	IV.
Common nouns,	64	57	57	66
Proper nouns,	2	4	2	6
Nouns or verbs,	21	24	34	22
Abstract nouns,	8	8	7	5
Adjectives or nouns,	4	6	0	0
Adjectives,	1	1	0	1

Each set was taken twice, with an interval of a month; the results of each first trial were not looked at nor thought about during the interval. Tables A and D show the order in which the sets were taken and repeated. Distraction was got by adding columns of logarithmic tables; five groups of these—vertical,—with five figures in each group, were taken as a stint; the plan followed was to add the first group, and while passing up to the next, to glance at the card, catch the word, and go on with the addition. The figures were at my right, the pack of cards at my left, and not to be seen save by special effort; the figures were covered either by thumb or by a card held in left hand, and were exposed singly. With concentrated attention the time allowed (fifteen seconds) was kept by a clock striking quarter-minutes. (Cf. Bergström, American Journal Psychology, Vol. VI, p. 248.) In this portion of the work the cards were on the table before me, hid by a block. As the clock was about to strike, I leaned forward with eyes on wall, and dropped them on the word at the stroke. All unrelated "associations" were ruled out, inhibited at once. At times this practice worked against the reception of some rightful though unrecognized claimants, and these, now and then, continued to press their claims until admitted, though often they were seen aright too late to be included within the time limit. After each trial the associations were jotted down, and then dropped from mind as quickly as possible. Work was usually done in hour shifts in the morning. Average time per word (inclusive of time taken to write out the associations, etc.) was with concentrated attention, 2.2 minutes; with distracted, 2.4 minutes. The latter is a little greater, but it includes the time taken to check the additions.

Because of differences in method it is impossible to make a sta-

tistical comparison with Galton's work,[1] but it may be well to call attention to the fact that Galton selected his words, and thus began with a set of associations; repetition of these would but fix them deeper. It is probable, too, that a large part of his list were suggested by matters new in his mind. As did Galton, so do we find any attempt at classification of one's mental furniture sure to be unsatisfactory. Eye, ear, and motor-mindedness may be convenient groupings in a discussion, but are inseparable in the mind. The conditions of the experiments were such as to cause a strong bias to internal speech. The words used were repeated mentally, and the process of association was with us begun often before the object for which the word stood was fairly realized; often not the object itself was got, but instead a strong sense of its location and place associates. Mere verbalisms, puns, catch phrases and the like were frequent; irrelevant pseudo-associations, *i. e.*, associations of associates, were a pest difficult to escape. It was less easy to pick out those cases wherein the eye was caught and associations suggested which were not strictly pertinent; by eye were often recalled derivatives of the root whence the keyword came,—though one could not be sure the associates did not join directly to the root-meaning. Visualization was common; localization was seldom absent. Results are as follows:

TABLE A. NUMBER AND DISTRIBUTION OF ASSOCIATIONS.

	1		2		3		4		Sum of $\alpha(1\text{-}4)$ a	Sum of $\beta(1\text{-}4)$a	Sum of $\beta(1\text{-}4)$b
	a	b	a	b	a	b	a	b			
I. *a*. Distracted Att.	116		130		74		17		337		
β. " "	52	49	87	61	44	36	15	6		198	152
	168		217		118		32				
II. *a*. Concentrated Att.	120		185		108		10		423		
β. " "	43	66	92	80	40	37	16	3		191	186
	163		277		148		26				
III. *a*. Distracted Att.	147		166		74		7		394		
β. Concentrated Att.	70	93	86	95	50	42	26	2		232	232
	217		252		124		33				
IV. *a*. Concentrated Att.	138		162		83		6		389		
β. Distracted "	41	89	80	92	43	36	22	5		186	222
	179		242		126		28				

1, First two-fifths of life; 2, second two-fifths; 3, last fifth, save 4, the immediate past.
a, New associations in first and second trials; b, repeats.

[1] Cf. Bibliography at end.

TABLE B. DISTRIBUTION OF ASSOCIATIONS WITH CONCENTRATION AND DISTRACTION.

	1	2	3	4	Sum	
Concentrated Attention,	371	525	281	58	1235	52.55%
Distracted Attention,	356	463	235	61	1115	47.45%
	727	988	516	119	2350	100.00%
Repeats,	297	328	151	16	792	

Table B is derived from Table A; *e. g.*, from column 1 a, 120+43+70+138 = 371; etc.

TABLE C. DISTRIBUTION BY PER CENTS.

Of the 2,350 new associations

		Concentrated.	Distracted.
30.93%	Come under 1,	15.78%	15.15%
42.04%	Come under 2,	22.34%	19.70%
21.96%	Come under 3,	11.96%	10.00%
5.07%	Come under 4,	2.47%	2.60%
100.00%		52.55%	47.45%

TABLE D. NEW ASSOCIATIONS ON SECOND TRIAL.

I. Distraction, followed by same,	337	62.99%
	198	37.01%
	535	100.00%
II. Concentration, followed by same,	423	68.89%
	191	31.11%
	614	100.00%
III. Distraction, followed by Concentration,	394	62.94%
	232	37.06%
	626	100.00%
IV. Concentration, followed by Distraction,	389	67.65%
	186	32.35%
	575	100.00%

Table D is derived from Table A, third and second columns from the right.

TABLE E. REPEATS ON SECOND TRIAL.

I. Distraction, followed by same,	337	100.00%
	152	45.10%
II. Concentration, followed by same,	423	100.00%
	186	44.00%
III. Distraction, followed by Concentration,	394	100.00%
	232	58.88%
IV. Concentration, followed by Distraction,	389	100.00%
	222	57.07%

Table E is derived from Table A. third and first columns from the right. Of 337 associates got on first trial, 152 recurred when the series was repeated a month later.

TABLE F. ASSOCIATIONS BY KIND; FIRST ASSOCIATIONS ONLY, NO REPEATS.

Concentrated Attention.

	Concrete.	Verb..	Story.	Word, &c.	Reason'g.	Sum.
II. 1 and 2,	230	28	153	114	81	606
III. 2,	87	13	41	58	33	232
IV. 1,	171	25	75	89	25	385
Sum,	488	66	269	261	139	1223
Percentage,	40	5.4	22.	21.3	11.4	

Distracted Attention.

I. 1 and 2,	214	19	143	93	48	517
III. 1,	175	34	83	76	23	391
IV. 2,	58	5	64	35	23	185
Sum,	447	58	290	204	94	1093
Percentage,	40.9	5.3	26.5	18.6	8.6	

Hampered by the conditions—in a limited time to get the greatest possible number of direct and good associations to a seen word,—the work was of course in some respects not normal. The number of associations got with concentrated is but little more than with distracted attention,—evidently because especial effort within the time limit was nearly equivalent to the distraction. Ranging was precluded by the conditions, though ranging is required in

order either to get new associations, or at least to dip into these when found. A comparison of sets III and IV, Table A (see especially the second column from the right, 232 against 186), indicates that to end an experiment with close attention enables one to clean up his scattered associations, though in several instances the commonest associates were not found. "Clock" gave me clocked stockings, but not a time-piece; "school" gave school of fish, and to school, *i. e.*, discipline one's-self, but not an inkling of the many schools attended or taught. In many cases it is difficult to satisfactorily assign the associations to their proper period of life. When they first occur—under the conditions of the experiment—they are most often fragments, nodes of a network, whose connections trouble either by lack or overabundance. One thing, however, is commonly well marked: that recent events are hard to remember when the stress is great. The period included under 4 was limited to a few days preceding the tests, and its incidents were sights, conversations and other such matters as are usually totally forgotten in a short time. Tables B and C show how slight, under the conditions, was the influence of attention. Of the determinants of association given by James (Vol. I, p. 577) recency and the oldest habits fall out in an examination of this sort.

Under D a comparison of I and III with II and IV, shows disturbing effect of distraction on first trials, since in I and III was got a less per cent. of the whole number of new associations than in II and IV. Yet an examination of the results of the second trials of the same sets shows no marked differences due to conditions of attention. In Table E, comparison of repeated associations, the most striking feature is the marked uniformity of the repeat-percentages under like requirements. The increase in the number of repeats shown in A and E, probably indicates growth in ease and habituation in performing the experiments, though it should be said that in the earlier part of the work, repeats, which returned with force, were turned down as unprofitable material, and greater effort was made to hold close to the key-word. As the work grew more familiar, the repeats were recognized, noted and passed with little trouble, and thus more of them found place in the final reckoning. Although the repeats were more or less bothersome, still from the start they seemed empty, persistent, yet worthless; as the work progressed they became less insistent, — mere echoes of the former trials. As the mind became adjusted to the conditions, the ideas which gathered about the key-word tended to form groups and to return *en bloc*. As for the addition, it soon ceased to be much of a distraction, in the sense of a source of flurry,—although when series of like or of small numbers occurred they proved to be very confusing. Accustomed to an irregular gait, both in the compulsory hunt for associates and in the addition of unlike numbers, the mind could only with great difficulty curb itself for a uniform series. Series such as 4-3-2-1-0, 2-2-2-2, or 5-1-5-1, would almost inevitably cause a break in the work. In fact the attempt to do orderly, *i. e.*, continuous, work was more distracting than the distraction, — true, of course, only because the conditions were such as to make the work an alternating one. Whether the alternation was from word to figure or from an associate back to the key-word (for it was required that each associate should be connected with the given cue), in either case irradiation, or growth of an idea, was hindered. Some words that suggested few associates occasioned slow diffusion about a centre (where the mind stuck), either through attempts at derivation, or by more or less

confused lines of reasoning. But these efforts tended to vagueness, whereas the conditions called for many and definite associations; and so it came about that fatigue, whereby the temptation to range was cut off, proved an aid to lessen the power of the distraction to control one's attention, and in this way permitted greater skipping.

A most striking feature of the work was the spatial setting given to almost all the associates save a few mere verbalisms. This localization was felt as a muscular tension toward the object named, which in turn needed a setting to give it the tang of reality. Almost equally necessary was the conscious inner arrangement of the associations, which had to be created into some muscle-tension form (usually a word) in order to be carried subject to recall. Words that offered little occasion for tangible (in the main visible) experience, and which for this reason had few concrete space locations, were usually confusing, *e. g.*, will, meditation. The confusion sprang from great familiarity with meanings which wanted concise muscular expressions; words with less used content, *e. g.*, continuity, plurality, were quickly placed in some book or conversation.

Refractory though the material was, a classification was made of it according to kind, as shown in Table F. The limits of these groups are as follows: Concrete, a well visualized object. Verb, some specific act suggested by the verb key-word. Story, recalled by key-word. Word, mere verbalisms, puns, proverbs, etc. Reasoning includes, in greater part, the cases of diffusion noted above. Examples are: with "nut" was associated Piñon Jay (*Gymnocitta cyanocephala*), which, though ruled out, hovered in the shadow until one of its synonyms—*nucifraga*—came up. "Enchantress" gave me *Circæa lutetiana*, the enchanter's night shade, and set my thoughts as follows: Night shade—a poison—poisons act on the body—so do Circean smiles; then came a vague notion of James' theory of emotions, and of controlling one by his emotions. The propriety of admitting this last group (reasoning) may seem questionable because its examples were not so directly referred to the key-word, yet in truth it is hard to say how many of even the verbalisms were got by a movement straight from the stimulus.[1]

C. Least Interval.

In the American Journal of Psychology, Vol. VI, is an article by Miss Alice J. Hamlin on the "Least Observable Interval between Stimuli addressed to Disparate Senses and to Different Organs of the Same Sense," wherein, pp. 572-3, are noted results of experiments with forced attention, and the conclusion "that voluntary attention is ineffective." The experiment of perceiving closely following stimuli with concentrated and distracted attention, was continued by the writer, with results as follows:

The apparatus used was composed of the pendulum circuit-breaker[2] in connection with (a) two telephones worked by the secondary circuits of sliding induction coils; (b) iron cups filled with water, into which were plunged the fore and middle fingers of each hand—shocks mediated by induction coils; (c) for a few trials a contrivance to produce a snap, when the stimuli were a shock to a hand and a snap by one ear, made as the current jumped a break. The interval for the click and also for the shock experiments was 24σ; that for the click-shock series was 31σ. In the case

[1] See also results of experiments on S. given in a note at the close of this article.
[2] American Journal Psychology, VI, p. 581.

of the former the interval was not "the least" which could have been used, but was taken because a range was desired within which attention could be manipulated; the interval used in the click-shock experiments was probably a little too short, as will be shown in another place. Our custom was to give an equal number of stimuli in R-L and L-R order, though of irregular sequence, in sets of twenty, save in the variable series, where forty made a set; each trial was preceded by a warning signal (click of a telegraph sounder) to ensure the subject's readiness. Operator and subject were in separate rooms, with only telegraphic connections.

1.

Work began with stimuli to separate organs of the same sense, in this case with clicks of medium intensity.

1. MEDIUM CLICKS.

DATE.	SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
		R.	L.	Right First.		Left First.	
				Att. right.	Att. left.	Att. right.	A. left.
Feb. 20-Mar. 8.	S.	75-87	75-80	49-41	44-59	43-88	48-75
Feb. 20-Mar. 7.	D.	100-90	100-72	53-57	50-90	46-87	54-50

In each column the figures first given represent the number of trials, the second set represents the percentage of correct answers.

With indifferent attention appears a trend to the right in both subjects. Both subjects also show that attention lessens the number of correct answers for the attended side. Attention to the left enables S. to overcome the bias to the right shown in the indifferent set; D. shows a strong tendency to go opposite the direction of attention. These features prevailed more or less throughout the work and will be commented on later.

Although the stimuli were adjusted so as to appear equal, and were tested before each sitting, yet they were almost always modified by subjective influences; for a time we were continually stopping for tests to see if the apparent differences in intensity were due to objective causes, and in order to neutralize any unavoidable differences in the apparatus, the terminals, telephones and cups were interchanged by sets, so that stimuli, *e. g.*, to the right side, should come an equal number of times through each terminal. As this matter of intensity played so large a rôle in the formation of order-judgments, our next experiment was with alternating series of medium and faint clicks—attention indifferent, since our aim was to get the naïve bias, if any. Of each group of four sets of twenty each, one and three—medium and faint respectively—were taken by one subject, two and four, duplicates of the other pair, by the second subject. Whilst as thus coupled there was much introspection on the "faints," yet when set off in series these were treated by the subjects apart from and with no conscious reference to the louder series.

2. CLICKS: MEDIUM AND FAINT. INDIFFERENT ATTENTION.

DATE.	SUBJECT.	MEDIUM.		FAINT.	
		Right First.	Left First.	Right First.	Left First.
Mar. 6-8, and 13-23.	S.	120-83.3	120-86.6	120-75.8	120-80.8
Mar. 6-8, and 13-23.	D.	120-81.0	120-78.0	120-79.0	120-70.0

In this group there is no trace of any bias to the right in S.; in D. it remains.

Continuing the comparison of intensities, we arranged the induction coils so they could be varied at the pleasure of the operator,—though the range of variation was limited to what was noted by each subject, *when testing*, as "just observably different." The series were short, and gave results as follows:

3. VARIABLE CLICKS: INDIFFERENT ATTENTION.

DATE.	SUBJECT.	Right First.		Left First.	
		R. Loud.	L. Loud.	R. Loud.	L. Loud.
April 5-10, June 10-19.	S.	79-63	79-75	78-77	79-72
April 6-10, June 10-12.	D.	45-11	49-86	45-96	48-58

Both subjects give preference to the faints; with D. the habit is extreme.

The electric-shock stimuli were used under the same general conditions of interval and order that governed in the use of telephones; the results of the main series are as here given.

4. SHOCKS: MEDIUM.

DATE.	SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
		R.	L.	Right First.		Left First.	
				Att. right.	Att. left.	Att. right.	A. left.
Apr. 12-May 9.	S.	200-93	200-45	103-86	97-76	97-41	103-64
Apr. 12-May 8.	D.	200-80	200-70	90-82	110-71	104-61	96-60

Note the bias to the right, especially in S. To direct attention to shocks is a very different matter than in the click series; this matter will be treated further under the introspective comments. In the same section will be noted an interesting illusion, found while we were working with crossed hands.

In order to test a lurking inference that voluntary attention did not aid, and possibly hindered, judgments of the time order, a few series were taken with "distracted attention," got by reading aloud, at a rapid rate, interesting "short stories." Each series was preceded by one of the usual kind—indifferent attention—in order to tune up our minds. The indifferent series was preceded by the customary ready signal; the stimuli of the distraction sets came unawares and at irregular intervals.

5. SHOCKS WITH DIVERTED ATTENTION:

DATE.	SUBJECT.	INDIFFERENT.		DIVERTED BY READ'G	
		R.	L.	R.	L.
May 30, and June 7-8.	S.	40-58	40-53	60-73	60-53
May 30, and June 7-8.	D.	50-64	50-60	60-75	60-61

The only effect seems to be to give the bias to the right greater play and thus to increase the whole number of correct answers on that side.

As with the clicks, so with the shocks were taken series with variable intensities. With one exception, when right led for D., both subjects went with the fainter intensity. But the series are too short to be more than suggestive.

6. SHOCKS: UNIFORM AND VARIABLE.

DATE.	SUBJECT.	UNIFORM, MEDIUM.		RIGHT FIRST.		LEFT FIRST.	
		R.	L.	R. Strong.	R. Faint.	L. Strong.	L. Faint.
June 20.	S.	20-55	20-55	20-60	20-80	20-50	20-80
June 20.	D.	20-85	20-80	20-60	20-55	20-65	20-80

2.

By means of telephone and cup, stimuli were given to disparate senses, one ear and the fore and middle fingers of one hand. The interval used was 31σ.

7. SHOCK AND CLICK.

DATE.	SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
		Shock.	Click.	Shock First.		Click First.	
				Att. on S.	Att. on C.	Att. on C.	Att. on S.
June 13-18.	S.	100-91	100-51	94-93	106-79	94-71	106-75
June 13-18.	D.	100-98	100-19	103-76	97-99	103-38	97-85

The most prominent feature of this series is the influence of directed attention to even up the very unequal portions got with indifferent attention. The readiest explanation of the facts is that the interval between stimuli was too short to permit the mind to adequately judge the order in the indifferent set, and that in the press the stronger, *i. e.*, more expansive, shock overbalanced the click. The interference of attention aided D. in that it served to turn his judgments in the contrary—and usually correct—direction.

It may be of interest to note the inner uniformity of the various series, and to this end the following tables, 8-11 inclusive, are submitted; figures give percentage of correct answers:

8. CLICK SERIES BY HALVES.

SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
			Right First.		Left First.	
	R.	L.	Att. Right.	Att. Left.	Att. Right.	Att. Left.
D. I.	88	72	64	92	96	38
D. II.	92	78	52	88	61	92
S. I.	100	71	53	57	86	86
S. II.	75	86	21	62	90	58

9. SHOCK SERIES BY HALVES.

SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
			Right First.		Left First.	
	R.	L.	Att. Right.	Att. Left.	Att. Right.	Att. Left,
D. I.	75	62	87	62	60	64
D. II.	85	78	78	80	61	57
S. I.	91	57	80	78	51	67
S. II.	95	33	94	75	33	60

10. CLICK AND SHOCK SERIES BY HALVES.

SUBJECT.	INDIFFERENT ATT.		DIRECTED ATTENTION.			
			Shock First.		Click First.	
	S.	C.	Att. Shock.	Att. Click.	Att. Click.	Att. Shock.
D. I.	96	18	78	100	24	82
D. II.	100	20	74	98	51	96
S. I.	90	52	96	84	67	71
S. II.	92	50	89	75	76	80

11. SERIES BY HALVES COMPOSED OF FIRST AND SECOND TEN OF EACH SET.

SUBJECT.	SERIES.	INDIFFERENT ATT.		DIRECTED ATTENTION.	
		I.	II.	I.	II.
D.	Clicks	77	79	70	73
D.	Shocks	75	75	67	70

3.

What, now, has introspection to say as to the subjective features of the work? Foremost is the fact, for D. at least, that the order of discrimination is from whole to parts; as the stimulus is repeated it grows in complexity. Other things being equal, in each new series and in every variation of a series, the judgments came promptly at first, and with a feeling of certainty that was fairly justified. But the feeling of ease passed away as introspection burrowed and disclosed differences before unsuspected. So it was that as we worked on, introspection notes accumulated at a growing rate, and we came at times to doubt the worth of series which actually showed a good preponderance of correct answers. Despite the fluctuations, however, two chief methods of judging were used: (1) A relatively immediate, sensory way, called "alert indifference" by Miss Hamlin (p. 574), and (2) a relatively conscious and reflective way. "*Relatively*," for we were not ordinarily conscious of such forms; whenever a case got loose from its immediate sensation-feeling, and thus made its order a matter of pure judgment, it was rejected, and the stimuli were repeated. Records were kept of these repeats (which do not figure in the tables given, and which were at times many), but as yet nothing definite has come from their study. For reasons to be given later, I believe these two forms of judgment to be stages of one process; nevertheless, to introspection the former is passive, the latter has a shade of action. Of the latter there are

two well-marked kinds, *a* and *b*. Mention has been made of the subjective differences interjected into the sensations by causes and ways thus far untraced; directed attention complicates the matter, but the reference now is to the indifferent attention sets, and chiefly to the fact that the intensities of each pair of stimuli differed subjectively, fluctuating capriciously both in degree and order. For a while the struggle—in cases when judgment lagged—was between a "feeling" and a "time" order, the two kinds listed above, *a* and *b*; introspection brought out that this time order depended on the relative intensities of the stimuli, which in turn were controlled by conditions of (1) end-organ responses, (2) general body state. One form of reasoning that slowly grew clear was: The two stimuli are objectively equal; subjectively they are unequal. One is fainter, hence farther away. But it cannot be more distant in space, hence it must have preceded the other. Another line of thought was: Into a uniform state of alert indifference or expectant attention comes a stimulus which, with a clear field, seems strong. Hard after the first comes a second, which by contrast seems faint. D. found himself controlled by the former—prejudice or bias rather than course of reasoning; S., and especially several on whom side tests were made, followed in part the latter. It should be kept in mind that the sensory, *i. e.*, passive, form—when got—furnished the most satisfactory results, because so free from any perception-fringe. An extreme of this form is found in the common experiences of life when two stimuli are separated by so great an interval as to leave no chance for doubt as to their order. The same feeling of sureness of order which accompanies the perception of well separated stimuli was present now and then, sometimes relating to isolated cases, again extending to whole series; yet the subjects at times were confident of what were, in reality, faulty sets, and again doubted correct ones. The individual cases checked immediately by D. as surely correct, give results as follows: (In each couplet the first number gives the whole number of cases checked "sure;" the second number gives the per cent. of correct answers.)

12.

Indifferent Attention.	Directed Attention.	Distracted Attention.
250-82	155-79	28-93

The freer one's mind is of anticipations of the stimuli, the better are his judgments.

The sensory form, recognized as purely passive, of course was beyond our control, and to be got only by a happy combination of circumstances. But commonly it was easy to sense the things we ought not to have done, for these were willful, though well-meant, interferences with perception. To direct attention is not an easy matter when one is prone to over-much introspection. Concentration on an ear was characterized by a strain in the ear muscles, and another, with a sense of looking fixedly, about the eyes. Attention to a hand often degenerated to a stupid stare until the plan was formed to slightly raise the hand, as if "hefting" it, at the same time slightly innervating the fingers. By this means attention was known to be *in* and not merely toward the hand, and "inner" and "outer" attention were made to coincide. The state known as

alert indifferent attention is really a state of general qualitative attention (for irrelevant matters are unheeded), with a focus of concentration in the median plane. Often during a series, as fixation grew more exact, what was at first a mere point of regard became a surface like the saddle-backed "specious present." The subject felt that the slightest wavering of attention to one side the imaginary centre would cause a bias in judgment to the favored side; then the criticism spread to his head, eyes, shoulders, and even to the equal expansion of the lungs. Because of this irradiation D. continually shifted his focus, ranging from a spot on the ceiling to one on his neck-tie, and tried some series with closed eyes. S., on the contrary, clung, as a rule, to a spot on the table at which he worked. Of the whole number of trials with directed attention, D. had 69% correct to S.'s 71%.

As might be expected in this interplay of fixation strains, there was now and then a passive state when the sensory form of judging found entrance. In truth these sensory judgments may safely be taken to mark the only times when attention was really alert and neutral, and the other cases, even of those in the nominally indifferent series, belong to more or less conscious work, as characterized by tensions. D., more troubled by introspective fancies, began early the practice noted above of putting himself into varying attitudes in order thereby to get new mental states, since the latter proved more favorable to the presence of the so-called passive judgments. S., on the other hand, was not troubled greatly by introspection until well on in the work, when he, too, became conscious of what seemed determining factors in the formation of judgments. A result of the change of method in his case is shown in the following table by the difference in the percentage of correct answers:

13. TABLE TO SHOW RESULT OF A CHANGE IN METHOD OF JUDGING.

DATE.	CLICKS.		DATE.	SHOCKS.	
	Indiff. Att.	Direc. Att.	Apr. 12-May 9.	Indiff. Att.	Direc. Att.
Feb. 20-Mar. 8.	83%	66%	First half.	74%	69%
June 11-19.	61%	67%	Second half.	64%	65%

Comparison of the earlier and later click series shows the superiority of the naïve form. The shock series, which came between the two click series, aids in tracing the gradual loss of the sensory form. In the first half the indifferent sets were judged largely by the sensory form; as the work progressed it became increasingly conscious. The different series as a whole show a growth in consciousness and *pari passu* of one's unfitness to serve as subject for such experiments as the present. We knew too much to be fit, although we worked exceedingly hard toward the end; the effort, probably, was what spoiled the work.

Because of our desire to be as free from bias as possible, we refrained in our conferences from the discussion of our introspective tendencies. For this reason exact comparisons of individual series

is impossible. But inspection of the tables, especially of No. 7, shows that one effect of voluntary attention is a falling off of the number of correct answers to the side or stimulus previously favored, and generally a marked increase to the side or stimulus before at a disadvantage. The result is, in part at least, due to interference with a physiological bias, and is accompanied by a change in the method of judging. Attention, when stimuli are to same sense, decreases the probability of correct answers; when to disparate senses, increases the probability.

14. PERCENTAGE OF CORRECT RESPONSES WHEN STIMULI ARE TO

SUBJECT.	SAME SENSE.[1]						DISPARATE SENSES.					
	Indifferent Att.			Directed Attention.			Indifferent Att.			Directed Attention.		
	Right.	Left.	Av.	Right.	Left.	Av.	Click.	Shock.	Av.	Click.	Shock.	Av.
S.	95	80	82	72	62	67	51	91	71	74	82	73
D.	78	70	74	80	63	71	19	98	59	61	87	74

This table must be taken with the following, which shows the

15. NUMBER OF TIMES WHEN JUDGMENT OF ORDER

COINCIDED WITH DIRECTION OF ATTENT'N.								WAS OPPOSITE THE ATTENTION.							
Whole number cases.	Subject.	Clicks. Correct.	Shocks. Correct.	Crossed hands.[2] Correct.	Average of the three series.	Click and shock. Correct.		Subject.	Clicks. Correct.	Shocks. Correct.	Crossed hands.[2] Correct.	Average of the three series.	Click and shock. Correct.		Whole number of cases.
466	D.	56-82	205-64	69-57	66	136-88		D.	104-65	195-71	11-56	68	284-67		594
	S.	83-54	206-75			188-82		S.	77-73	194-59			210-77		

A little more than a fourth oftener, the judgments went counter to the direction of attention, though there was a slightly greater number of correct answers with than against—72% and 68% respectively. But with such results it is in place to ask, what are the results of voluntary attention? They are complex. (1) There is a general tendency to throw doubtful cases in the direction of the attention. In numbers of places the introspective note added to the subject's order-record is, "Uncertain; go with attention." (Unless there was good reason, objective or subjective, for the rejection of a trial, it was checked, even though

[1] Sum of click and of shock series.
[2] See p. 550. First number of each couplet gives the "number of times"; second number, the per cent. of correct answers.

the order-judgment was obscure; else should we never have finished a set after our critical mood was well seated.) Yet doubtful cases were little if any more prevalent in the state called "directed" than in that called "indifferent;"—as shown by Table 12, the number of "sure" answers is but three per cent. greater in the latter. The notes of S. lead him to infer that high grade, *i. e.*, very well concentrated, attention, tends to draw the judgment with it; his figures are as follows, for the click-shock series only:

16.

High Grade of Attention.				Low Grade of Attention.			
Shock First.		Click First.		Shock First.		Click First.	
Att. Shock.	Att. Click.	Att. Shock.	Att. Click.	Att. Shock.	Att. Click.	Att. Shock.	Att. Click.
29-100	27-67	17-59	36-89	65-89	79-84	89-79	58-60

Yet, as has been so often said, our record was a growing one, expanded as difficulties arose; hence it does not extend alike to all the series. What we should have passed as unquestioned good attention at one time, a month later would be found seamy. D.'s record, so far as available, for cases when the attention was felt to be good and the order of judgment was with the attention, shows 93% of correct answers as against 74% correct when judgments went counter good attention. (These are from cases listed in Table 15, and are characterized by a good degree of concentration. They differ from the cases recorded in Table 12, also, in that those have reference to certainty of judgment.) At first the record seems to make good a claim that attention is an aid, but comparison with the "Distracted Attention" series—Table 12—shows another 93% got under conditions the opposite of attentive.

(2) The most marked subjective effect of directed attention, for D. at least, was the weakening of the stimuli. Ordinary attention to a stimulus is usually accompanied by an increase in the relative prominence of the latter in consciousness,—for simplicity, say its intensity; (we will leave aside any reference to, *e. g.*, dreaded danger which vanishes when bravely met). When the stimuli, clicks or shocks, were tested, preliminary to the regular series, to ensure likeness, they were easily compared and equalized. Then, as the experimenting went on, it became increasingly difficult to sense them, especially the faint ones. This loss was not due to fatigue, *i. e.*, to exhaustion of the part concerned, because a return to the test-attitude of mind revived the stimuli. That it was the result of an attention-strain seems evident from a study of the growth of the introspection notes. In the early part of the work, stops to overhaul the apparatus with the intent to find in it an objective cause for intensity-variations, were frequent; but when fairly in on the shock series, we found that to throw the attention well into a hand was equivalent to diminishing the intensity of the stimulus to that hand. Not that this result always came, for there are several comments of surprise at pairs that came equal or even with intensities the reverse of that noted above. When we reached the click-shock series, the influence of attention was very marked. The

indifferent series indicates an almost complete subjection to the shock; but when attention was given the hand, the shock-stimulus was usually weakened, and at times to so great an extent as to leave room for doubt whether it had really been sensed or only expected. The only series from which can be taken individual cases specifically noted, is the click-shock one, as follows:

17. TIMES WHEN ORDER WENT

SUBJECT.	WITH ATTENTION AND		AGAINST THE ATTENTION AND	
	With Faint.	With Strong.	With Faint.	With Strong.
D.	32	5	17	91

In this click-shock series the case for S. when the shock leads, is like that in the shock series (Table 5), and when the click leads, like that in the click series (Table 1). That is, in the former the number of correct answers and the direction of attention go together; in the latter they separate. The same is true for Miss Hamlin (in unpublished tables), but not for D., who varied his attitude often, but held to the original bias of faint intensity and priority. Because of this bias to "faint, therefore first" (p 545), a likeness marked as most appropriate suggested itself to Cinderella,—quiet before her assertive rivals, yet recognized finally, by her quality, as the true leader. Probably the comparison is only an elaboration of the struggle present from the outset, between a "feeling" and a "time" order, *i. e.*, faint and strong intensity.

The occurrence of the ghost-like after-image of the shock which persisted in the hand until it was given notice, though the original shock had been ignored, marks for introspection a difference between the so-called inner and outer forms of attention, — because the after-image (and oversight of its original) was most common when attention was most strongly concentrated on the hand. So far as inner attention is concerned, the appended table shows that with D. the judgment goes with the direction of attention. When stimulus and attention are on the right side (left hand), or *vice versa*, by making many wrong answers for the opposite side, the subject raises the number of correct answers *with* attention, to a good figure. But the particular difficulty found in this series lay in the location of the shocks, a feature that comes out more markedly in the trials with indifferent attention. In order to get 137 answers to a R. first series, there were given 285 trials; to get 144 answers to a L. first series, were given 247 trials. The shocks would not remain in the hands, but they gravitated to or toward the median plane. At times their fusion was complete on the Cyclopean eye order; very often it was partial, as when the right-side shock remained in place whilst the left-side shock approached it more or less.

18. "CROSSED HANDS" SERIES.

SUBJECT.	INDIFFERENT ATTENTION.						DIRECTED ATTENTION.									
	R. First.			L. First.			Right First.					Left First.				
	a	Ans.	b	a	Ans.	b	a	I	b	II	b	a	I	b	II	b
D.	285	137	89	247	144	67	50	26	20	24	5	47	23	1	24	19

a, Number of trials; *Ans.*, number of answers; *b*, correct answers; I, attention to right; II, attention to left.

Of the cases of total disappearance of stimulus there were on the right side (*i. e.*, from left hand), forty-two; from the left side (right hand), sixty-six. Twenty-one of these disappearances came in groups of three or more; the remainder were scattered or in couplets. The total loss of one stimulus is probably the extreme of translocation. The illusion is probably due to the fact the median plane is the most favorable region for sensory focus; here, or in right-handed people when confused a little to the right of it, would be projected ordinary stimuli sensed under unusual conditions.

In general it may be said of this section of our experiments that voluntary attention aids one to break up the course of his normal errors, or constant bias (cf. Tables 4 and 13). Aid is got by attending to the weaker stimulus of a pair given to disparate senses (cf. Table 7), because so to do is to inhibit in some degree the response to the stronger. It does not follow that results will be bettered by this attention; that can be seen only when the entailed disturbance ceases and action becomes again uniformly adjusted. For example, in the single-sense series "inner and outer" attention were normally balanced and the judgments were fairly correct. But in the disparate-senses series it was necessary—to attain an aim—to shake off the dominance of the shock; any means to do so would have the result got—of equalizing the number of answers for the two senses. In this way is it that attention is so effective in producing illusions, inverting time-order and the like, because the process set up by its interference is unlike the ordinary procedure it disturbs. Manifestly, attention may confuse as well as make clear. The disturbing effect of attention's strain to be inferred from the tables given, is confirmed by two side series carried on with Mr. G. W. A. Luckey, using medium and faint (*i. e.*, just perceptible) clicks, R. and L. leading in irregular alternation. The subject aimed to hold himself "alertly indifferent" throughout the series.

19.

MEDIUM.		FAINT	
Number Given.	Per Cent. Correct.	Number Given.	Per Cent. Correct.
500	83	460	76

To get the faint clicks it was necessary for him to tense to a high degree, and this effort brought on a fatigue of "indifference" which was fully as exhausting as one from great "concentration." As the muscles of response tired (from whatever cause), the consciousness dulled. In connection herewith may be inserted a statement of the whole number of correct answers given by S. and D. in all the series under discussion.

20.

Subject.	Indifferent Attention.	Directed Attention.
	Per Cent. Correct.	Per Cent. Correct.
S.	70	70
D.	76	69

If we extend our survey to the three sections under which our experiments were conducted, it is safe to make the following statements:

1. Attention is an aid in those reaction-time experiments in which the aim is to reproduce a given series—be it muscular or associational,—because in these the general conditions, as well as the especial incidents which a subject soon comes to make use of, serve to give cues. Thus one is enabled to "perceive the probable," and the expedited reproduction of the anticipated response at times leads to the *vorzeitige* reaction.

2. Attention may or may not aid in association, or rather, in the recall of associations, when we take note only of quantity. When regard is given for the presence of familiar associations, such as would be expected to appear first in ordinary stages of attention, the attention strain proves a hindrance.

3. Active attention is a positive detriment in new work whose cases must be decided each for itself. The kernel of active attention is prevision, and always prevision of an act. If the strain be great enough, instead of facilitating perception, it weakens the intensity of the first stimulus and thereby makes it other than what we await.

We may go further and characterize as disadvantageous attention when applied to the details of any work, in so far as regard is had for quick and correct execution; for acts that can be done quickly are habitual,—any interference with them, by means of attention, is in its very nature the putting of undue stress (or tension) on one link. In brief, attention is an aid to speed and surety only when and in so far as the conditions are the reproduction of a known series, *i. e.*, the reinstatement of the probable; and it is thus helpful only when the conditions converge on the few possibilities that are to be given. Active attention aids in attaining new conceptions by interfering with a habit series, thus making possible a change in direction of discharge. Passive attention aids by suspending actions that if under way are possible diversions, thus giving the stimulus a clear road to follow in the most habitual mode. The two are phases of every act, and are meaningless apart; nor can one be sure, in strange conditions, if his attention effort will be profitable or the reverse.

II.

Before continuing further the discussion of observations made whilst carrying out these experiments, it will be well to review briefly the problems of attention as these are now formulated. For the present purpose it is advisable to restrict our historical survey to the empirical psychologists, and of these to begin with Condillac, because of his elaborate theory.

Fancy a statue, says Condillac, built within on the plan of a human body, but with all inlets (senses) closed, and under the control of a master who opens them at pleasure. The statue is in every respect like a man, save it is absolutely devoid of ideas. By manipulation of the sensations ideas are built up, for judgment, reflection, desires, passions, etc., are only sensations which transform themselves differently (1-pp. 39, 40). The first sense opened is smell. The statue, modified by contact with an odor, knows a new state, though what this is, in our terms is unknown. With this sensation and the knowledge of it, appears also attention; to sense, know and attend to are one and the same. Henceforward experiences are attended by pleasure and pain (1-pp. 44, 45). In an analysis of the faculties of the mind, Condillac distinguishes between a general view of a landscape and a discernment of a particular object in the scene. This look, by which the eye tends to the object on which it is directed, is an action; for this reason it is called attention; this direction of the organ is the only part the body has in attention. On the part of the mind, attention is one sensation, experienced as though it were the only one, *i. e.*, it is an exclusive sensation. Comparison is a double attention (2-pp. 363, 364). To return to the statue: The odor which the statue senses does not vanish so soon as its source ceases to act on the nose. The attention given it retains it, *i. e.*, there remains an impress more or less strong, in accord with the degree of attention. Behold the memory! (1-pp. 48, 49) Possessed with a memory, the statue is a person, though all his psychic life is expressed in terms of smell (1-p. 89); this individuality is shown in the use of the personal pronoun. Why does the statue say I? Because we think only in words. Language is expression, and the elements of the language of action are innate (2-pp. 401, 402). Since the mind can never get away from sensation (1-p. 3), the work of reason is to clear up what was implicit in former experience. For, while the first sensation-contact does not produce a full idea, subsequent ones do so, and these, he assumes, know as we know them (1-p. 89). Evidently Condillac confuses contact, sensation and perception, and by piling up many of the first, believes himself able to produce the last. Looking as he did for all plus to come from without, he puts attention at the gate, and sees its presence in the action, as shown in the adaptation of the sense-organ that conditions the reception of an impression. This readiness is an integral part of the sensation, and the more exclusive the sensation, of necessity, by definition, the greater the attention.

It is easy to cross-question Condillac into confusion. If the statue knows its new state, why should it not know its former condition, prior to all sensation? Evidently the "I" that marks the advent of personality is not a smell term. His explanation of the origin of memory is rank tautology. Yet he helped set the trend of interest in mind-study toward the expression side, and experimentation, while it has made ground for the science of psychology, has also helped to make clear the unsoundness of some of the earlier assumptions.

Speaking broadly, we may say those who yet hold views on attention like Condillac's, know little of experiments; for them there is no need to demonstrate psychic power.[1] This point should be kept in mind, for too commonly it is assumed that experimental psychologists are not psychologists at all, but physicists who are anxious to reduce all life to terms of motion. But the distinction felt by Condillac, between consciousness and its content, though blurred in his words, is quite as real as is the intimate body-mind connection he noted, and these two phases are inseparable in any full study. At first the experiments in psychology were scattering. Bessell's solution in 1822 of the personal equation, Helmholtz's measurement of rate of transmission of an impulse through a nerve, 1850, Fechner's "Psycho-Physik," 1860, and, finally, Donder's work in 1861, are matters that serve to show how the problem of attention, as a subject for experiment, gradually came to the fore. Fechner was a pretty thorough-going advocate of the Attention-is-in-the muscles theory, and from the appearance of the Psycho-Physik there was much work done in German psychology which involved the use of attention. "Since the suggestive dissertation of Herbart in 1822 *(De Attentionis mensura causisque primaris)*, attention has come to play a very important rôle with psychologists, with whom it has had much to do in undermining the theory of faculties, until, as is known, with Wundt it may be called the central psychic category."[2] In 1873 Exner published his *Experimentelle Untersuchung der Einfachsten Psychischen Processe*, in which great stress is laid on attention. Besides the studies of Helmholtz, there appeared within the space of a few years the advance guard of the host of modern psychologies: Delbœuf, 1872; Hering, 1861-75; Brentano, 1874; and in 1874 Wundt's first edition.

Wundt's aim was to make psychology explicative, and for this purpose he made use of measurement. He starts from the psychic side, and his interest is chiefly in the unification of experience, his "Apperception." "One might say the last great step in Psychology was taken when Wundt pointed out the incompleteness of the English Association theory," says Lange (p. 395). To Wundt the natural expansion of the unitary nature of mind constitutes reason, and by definition of its nature, precludes the possibility of thinking more than one thought at a time. His psychology rests on this, that there is a physiological, or unconscious, basis for sensation; once given sensations, *i. e.*, psychic facts, and reasoning is inevitable. The impression I get is that Wundt makes little of the "unconscious" as a field of study. He calls the muscular form of reaction a pure reflex, destitute of any psychic worth (1, II p. 310), and though he hopes we may learn more of the "physical dispositions" left by sensations, he doubts if their study can throw light on the origin of the "psychic dispositions" (4th ed. II, 265). In the first edition (4th Abschnitt, 18th Capitel) he holds that the elements which are yet without (on the nascent side of) consciousness do not have a unity. Despite the fact that ideas seem to pop into consciousness fully formed, their unity is given them by consciousness only. Wundt is not one who believes in a stream of thought; the break between the apperception of *A* and that of *B*, he says, is due to the fact the mind must turn from *A* to *B*; and again, our perception of time is due to the nature of apperception,—the mind must go in jumps (4th ed. II, 429f.). In the first edition (p. 717) we read: "Because in the synthesis of feelings *(Empfindungen)* and in

[1] *Vide* Spencer's "Inadequacy of Natural Selection," *Pop. Sci. Mo.*, XLII, p. 801, n.
[2] G. Stanley Hall, *Mind*, 1883, p. 177.

the association of ideas *(Vorstellungen)* consciousness comprehends itself as active, that outering of it arises which we call attention. Manifestly in any moment consciousness has not made equally prominent all the inter-relations of ideas, but has turned almost exclusively to a few. This feature may with advantage be compared with the action of the eye, and the focusing of consciousness be called inner sight."? At this time, it seems, Wundt's ideas were simple; attention was the expression (in muscles) of the working of consciousness. But the fourth edition reveals how little importance he attaches to expression, and how fully he is under the spell of his *Blickpunkt* figure. Just how many and what parts of the process whereby sensations are received and elaborated are physiological—according to his theory,—Wundt does not make clear; but to him, now, attention is a feeling which accompanies psychic activity, and feelings thus far are treated by psychologists in a cursory fashion—in lump. This activity which underlies is apperception, a strictly psychological fact, and to it Wundt devotes his study; the physiological accompaniments, so called, get little of his notice. Sufficient for him is it that apperception and not the intensity and *quality* of a stimulus determines the line of sight (I, II, 121). Consciousness is a *Blickfeld*. Wundt assumed his inner force, and busied himself with experiments to determine how rapidly it could act under certain factitious conditions. His consciousness is closely held to his inner *fovea*, and to use his own expression, what exists outside the circle of clearest vision, is ignored; of ideas outside clear consciousness we can say nothing, save historically.

Coincident with Wundt's first edition is G. E. Müller's *Zur Theorie der sinnlichen Aufmerksamkeit*, a study which emphasizes the difference between outer and inner attention, and finds the former to be dependent on the latter. Dualistic interaction must, on rational grounds, be possible (p. 3). Not the objective intensity of the stimulus-effect, but the perception, is increased by attention (p. 4). Sense-attention is the reinstatement of certain conditions of the sense-organs (p. 50). If nerve-cells can act on mind, then mind can act on nerve-cells; since mind can act on motor nerves, it is reasonable to suppose it can act on sensory nerves (p. 3). Images or vibrations travel down sensory nerves and modify incoming sensations (pp. 86, 87). A mental state in possession of the field can bar out rivals. In voluntary sense-attention the mind consciously gives the desired adjustment to the sense-organs; but objects have the power to suggest the same adjustment which is made involuntarily by the mind (p. 110). These extracts serve to give fairly well the general standpoint of the Leipzig school. Sense-attention is a minor matter to psychologists, and is dependent on inner initiative.

In 1888 Nicolai Lange published his *Beiträge zur Theorie der sinnlichen Aufmerksamkeit und der activen Apperception*, in which he more definitely stated the subordinate value of sense-attention. Were it not for the mental power to attend to faint impressions and to ideas, our minds would be open to all the blasts of experience; in which case even the sense-impressions themselves would have no meaning, because of no interpreter at the center (p. 391). Active attention consists in intensifying one idea-complex by the aid of another; it acts after ideas are in the mind. For long no other explanation was given why attention flickers than: it is the nature of apperception so to do. It was said the fixated idea was held by an act of will; or, that opposing ideas were inhibited. Lange passed by these reasons, and endeavored by experiment to show the variations were due to the coming and going in the mind of images of the fixated stimulus. Sense-attention, then, consists

in the assimilation of a sensation by its corresponding memory image which has been actively recalled. These images can be recovered actively only by means of voluntary innervation or movement impulses which are associated with them. This process we call active apperception. The variations in active apperception are conditioned by the general relativity of psychic phenomena, and form the cause of all other periodicities in consciousness, such as are expressed by sense-attention in the time-sense and in the periodic phenomena of memory (pp. 421-422). This theory of sense-attention (which Wundt adopts), demanding an inner image, to which the sensation is assimilated, is the old problem of perception, and reminds one of Parmenides' "Like is known by like." Probably in Wundt's mind the resemblance is only superficial; but I find it hard to get Wundt's position clearly.

Ludwig Lange, in the same volume of the *Studien* (IV, pp. 479-510) published a report of his *Neue Experimente über den Vorgang der einfachen Reaction auf Sinneseindrücke*, wherein he noted two very distinct methods of reaction — the muscular and the sensorial. These are too well known (in words) to require description. Wundt adopted the conclusions of the Langes. The work of the one gave him a criterion whereby to reject all experimental study in psychology which does not proceed on the Wundtian lines; that of the other furnishes reinforcement to his apperception-centre theory. The Langes, in harmony with their teacher's position, consistently refuse to extend their study as *experimental psychologists* into the field of "the unconscious," or the physiological.

It is not my wish to exploit the controversies that have arisen over Wundt's theses,—some of which are bitter. The opposing camps are separated more by innate tendencies or philosophical bias than by differences of fact. Some men by nature cling fast to the tangible. It is easy to say they take short-sighted views, and give but partial accounts of the problems they investigate; they grant the truth of the charge, and try to remove it by discovering more. Their results are but fragments; we need not look to them for complete theories. Two of these it will suffice to mention.

In 1889 appeared Ribot's *Psychologie de l'Attention*, comparable in its general method of treatment, critical, with Müller's *Zur Theorie der sinnlichen Aufmerksamkeit*. Müller's great interest centred on the psychic initiative, Ribot's on the mechanism of attention. Ribot recognizes the subjective aspect of psychic phenomena and asks, what are its bodily conditions? These he finds in the more or less isolated (differentiated) muscular tensions, which in turn call into action limited portions of the nervous system. The ordinary round of life exercises the brain normally, that is to say, all parts function in an habitual way; new conditions disturb this equilibrium and the new tensions arouse new cerebral arrangements, and thus produce the states *known* as spontaneous (natural) or voluntary (artificial) attention.

But it is to Münsterberg we must turn for experimental investigation of the motor basis of attention. Much has been made of the antagonism between the views of Münsterberg and those of Wundt, yet, as has been said, the difference rests more on innate bias and method than on fact. To one attention is a feeling, to the other it includes the activity behind the feeling. After Wundt adopted the conclusions of the two Langes, the whole Leipzig school felt obligated to close one portion of the field to experiment; whereas Münsterberg, believing there is a province of psychological *phenomena*, set himself to trace these phenomena. Münsterberg maintains the distinctively psychological feature of this study, but sees

no reason to halt so long as there are "physiological" facts with psychological meaning. The results of the Langes gave points of attack, and in the following year (1889) appeared Münsterberg's *Beiträge*, I and II. In the first are set two problems. (1) May not the psychic results reached by voluntarily exerted *Vorstellungsbewegungen* be got without the conscious use of will? (2) Is it possible, by studying judgments whose premises are variable, to find the spot in the psychic mechanism that concerns the transition from passive to active *Vorstellungsbewegungen*? (1-pp. 67-68.) "To him who endeavors to so set forth the psychophysical theory that all the phenomena of consciousness can be referred to changes in the physically conditioned contents of consciousness, no greater bar to progress exists than the distinction between the field of non-voluntary association and that of voluntary *Vorstellungsbewegungen*" (p. 64). The sensory form of reaction requires more time, say Lange and Wundt, because it includes the times needed for perception, apperception, volition and innervation; the muscular form is a mere physiological reflex. The former is open to great variation in time, but has a sure outcome; the latter is uniform in time, but liable to error. Can I get results qualitatively sensory, and which (per theory) are attainable only by the sensory form of reaction, by using the muscular form? asked Münsterberg. He did. The judgments given (as results in his experiments) are such as ordinarily require reflection and choice; the times correspond to the motor requirements.[1] Manifestly, "of any sequence of the various acts we cannot speak; yet with this sequence stands or falls the apperception theory" (p. 121). Ordinary consciousness distinguishes voluntary and involuntary mental acts, and is supported by the prevalent psychological school, as represented by Wundt, which sharply separates apperception and association, denies the former is derived from the latter, and affirms that choice and judgment are not influenced by the contents of consciousness, but are basal. The apperception theory is safe so long as it remains within the psychic sphere. But when we think of the brain and the result of physical changes there on the content of consciousness, we see the two are not separate; physical dependence must be related to physical causation (cf. pp. 107-108). Even though the short form be as Wundt says, a mere reflex, yet "I believe it is competent to form a point of departure for the investigation of complicated psychic acts" (p. 110). In cases of pure apperception the time should be shortest, according to Wundt, when attention is on the first member of the series, the signal; Münsterberg found it to be shortest, in the sensory form, when attention was on the last member, the movement (p. 114, 115). If, one may ask, both reaction forms have psychic worth, how account for their differences? Münsterberg's reply is, most of the work is done, in the motor form, before the measured part of the experiment begins (p. 171). When the conditions are known and the order is to react quickly,

[1]The work, in brief, is as follows: With a five-fingered keyboard and five classes or possibilities of answers, the subject makes in the shortest time a finger movement to express a reply to a problem given by the operator. *E. g.*: In the seventh series of experiments, with fingers assigned to groups: Poets, Musicians, Naturalists, Philosophers, Statesmen, a name—*e. g.*, Locke—was to be listed under the heading Philosophers. In this series the average time taken when the sensory reaction was used, was 1122σ; with the muscular form, but 437σ. The second part of the work was given to a comparison of free association with acts of simple judgment. Beginning with random association the experiment was conditioned, both subjectively and objectively, until complicated judgments were called for, yet the reaction-times did not increase in like ratio so long as the short form was used.

the will to act already exists in the idea when perceived. Thus it is the reaction is made before the signal has roused what we call "its meaning" in the mind, before it is apperceived, and before any relation between it and the reaction has found a verbal judgment (p. 166).

Part II of the *Beiträge* contains an article, *Schwankungen der Aufmerksamkeit*, wherein is detailed a re-examination of the work on which N. Lange based his theory of inner initiative for sense attention. Wundt's first care is to preserve the unity of consciousness, Münsterberg's is to preserve psychophysics. If we say consciousness can turn away from one part of its content to another, like the physical eye, then psychophysics is at an end (pp. 70-71 and 123). The outcome of this study is that the contents of consciousness and not consciousness itself, change with the variations of attention, and that these variations are due to peripheral causes (*e. g.*, muscle fatigue) and not to presence or absence of an inner assimilating memory image. "I believe my experiments point to that conclusion which Lange rejected, namely: these variations are conditioned peripherally and not centrally. Understand me; I do not say that attention in general is only a peripheral phenomenon, nor that all variations in the content of our consciousness find their psychophysical cause outside the central organs; I do not say that alterations of our special cases run on unconnected with central reflex paths, but I believe that this particular effect, the coming and going of the perception, is due to changes within the sphere of the contributing sense organs" (p. 94). In *Die Association successiven Vorstellungen* Münsterberg (3) describes a study of the question: Is the reproduction of ideas determined by an inner relationship alone, or must there be an outer link, arising from the simultaneity or sequence of the stimuli? He decides for the latter, and holds that idea *a* dissolves itself in the innervation that makes the tension which calls up *b*. It lies in the nature of the muscular system to associate its movements serially on reflex lines; hence one movement is the stimulus for its successor. The various stages of this series are reflected—in consciousness—as associated ideas. Münsterberg employed the memory-span test, using letters seen singly. His first group was made with free attention; the second group was with attention distracted by mental arithmetical problems performed aloud. In the latter group his ability to reproduce the series was much diminished because the vocal apparatus was so employed as to prevent utterance of the names of the letters seen.

The fight is still on. Each side believes in a psychic force—the motive power; each believes objects can arouse this force. The one takes the mind after it knows what it does and says that all which goes before is inscrutable to psychology (but cf. Wundt, 1-II, p. 279); the other trenches on this preserve, and sees in the connection of feeling and muscle tensions a preliminary stage in the formation of ideas which is fairly safe matter for the psychologist's study. It may be said the efforts of the one are on Kantian lines to push "understanding" back into the territory of sense (cf. Wundt's innervation theory, and passive apperception); of the other, to advance "mere association," brain processes and muscle tensions, into the field of mind. In Vol. VIII, *Philosophische Studien*, are articles by Eckener and Pace, based on re-examinations of the contradictory experiments of N. Lange and Münsterberg, which claim to substantiate Lange's conclusions. The matter reminds us of the claims made for the innervation theory. The latter was plausible, but when, after long dodging it did give tangible

"proof," this became aid to its opponents. The conclusions of those who defend the inner initiative must always rest on inference; their proofs when brought into the field of action become Pyrrhic elephants.

III.

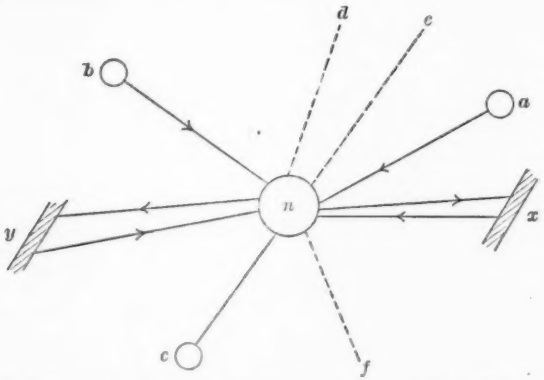
After one has been working in a given field for some, time there grows up in his mind an almost unconscious attitude toward the subject of his study,—the result of his reading and experience. It is hard to describe this position simply, because in its darker parts there lie all the explanation and harmonization one needs; these are felt to be there, even if not evident to a critic. Yet some clue to a writer's bias is helpful; hence the following statement of the thesis maintained in this paper, given with the hope the argument will be examined to learn the meaning put into the words used.

A popular psychological assumption is that mind is awakened by stimuli from without,—the production of sensations. This view may be put thus: *S* O———o *s*, in which *S* represents the central system, *s* a sense organ. A stimulus in *s* passes to *S*, and there is known. From *S* in turn the stimulus-force, or idea-force as it should now be called, passes out to other parts of the organism. Whether it passes on motor nerves only, is in dispute. G. E. Müller, resting on Helmholtz's experiments, claims an idea can and does retrace the sensory path and awaken in the end-organ sensation. Wundt, James, and most psychologists hold that consciousness is an inner force that expends itself at will—on motor lines; Bain makes much of inner spontaneity plus fortuitous combinations of desires and movements, which enable the mind to satisfy its wants. Wundt, James, Müller and others hold to inner association and arrangement of ideas. Opposed to them are Bain, Münsterberg, Ribot, Féré, who hold to muscular successions that condition association. The former teach that consciousness precedes and directs attention; the latter claim it follows the muscle tensions that are "attention." The position most in accord with the common understanding of our subject is that held by the men of the inner initiative. *E. g.*, for Prof. James "selective attention" gives us what we call sensations, *i. e.*, picks out certain vibrations and arranges them in the order in which they come to consciousness; Wundt's apperception theory is akin. This mobile inner force can so deploy its energy as to facilitate sensation by preparing the end-organs for the reception of stimuli, and even, as some claim, by anticipating in the sensory nerves the stimulation; it also helps us to perceive, conceive, discriminate and remember; it gives us time-order and ideas of number; it quickens reactions; it both magnifies and suppresses feelings and ideas; it interferes with our bodily functions. But experience shows us that attention is not always controlled from within, and to meet the need names are given, *e. g.*, reflex and conscious, involuntary and voluntary, and passive and active, whereby it is hoped the attention forms may be classified. Here again disagreement prevails; to the strenuous advocates of an inner force a self-directed activity can be neither reflex nor involuntary. Wundt, in the fourth edition (I, II p. 278), lapses somewhat, gives up the terms voluntary and involuntary, and claims that attention is characterized by passive and active features, and that the former always precedes the latter. This inner-activity view is one that as a whole lends itself to easy comprehension; only when its bases are touched does it disclose gaps. Against it are several theories. Spencer treats the mind from a totally different stand-

point, and so ignores attention; to Ward it is one of the fundamental divisions of mind. Yet another position, and one that in some respects meets with favor because of its tangible reference, is that attention considered on its psychic side is only a state corresponding to a physiological state of activity in the muscles. The advocates of this view—to speak in a general way—are Bain, Münsterberg, Ribot, Féré. No two of these men agree throughout, yet for general purposes the classification may stand.

The remainder of this section will be given to an attempt to formulate a working hypothesis of a view that sees in attention *per se* a muscular basis. The effort will be to apply in another way what has been in the air so long as to be general property; *e. g.*, Hall's insistence on motion as the basal psychic fact, James' emotion theory, Münsterberg's muscle-link for association, and the many minor studies akin to Lehmann's.

The annexed figure may illustrate the process wherein ideas are made manifest.



a b c are sense organs; *n* is the central nervous system; *x* a muscle group whose tension proves favorable to use of *a*; *y*, muscle group that becomes connected with *b*; *d e f*, other muscle groups, some or all of which may, and at times do, tense simultaneously with *x* or *y*, or both.

Assume the discharge into *x* is definite. Then my thesis is: When the stimulus comes via *a*, it must end in *x* before consciousness can be said to exist. The process *a-n-x* is an indecomposable unit which corresponds to the single state of consciousness that knows (or is known as) the given sensation. *a n x* gives the sensation-tone, the qualitative characteristic of the particular experience; but, alone, it is in no general sense of the word to be considered as "known." *a n x* is the condition of a bare sensation (in so far as such an abstraction can be considered); the conditions of knowing *a-n-x* are the related tensions in *y-d-f*. But the discharge from *n* is seldom if ever exclusively into *x*, though it is assumed the greater part is so sent; instead it irradiates and sets up a general readjustment, into which comes a new disturbing factor in the incoming sensation from the tension of *x*. This latter state, *i. e.*, the reception and assimilation of *x*'s tension-sensation, gives us knowledge about the former *a-n-x*

state. a-n-x gives a simple idea; if it can be said to be known at all, it is absolutely relationless; no attention can be given it until its final term has been referred back to n and redistributed. Thus comes the claim that attention, as a psychic fact, follows and depends on the muscle tension, and we do not attend to an idea until after the idea-stimulus has run its course. The links that connect our ideas and bring them into the field of consciousness are these kinæsthetic sensations, and our personal power is shown in rejecting some and holding to others. As our bodies could go nowhere save for bone resistance, so our mind's endeavors would be fruitless without muscle objectification. It may be the stimulus that reaches n is of a kind or degree that has no preferred outlet; in this case the many and inharmonious tensions produce a state of emotion, *e. g.*, fear, with beating heart, panting breath, protruding eyes. Normally, however, one path does get preëminence, and the sensation gets a relatively definite name or expression—in vocal cords, facial muscles, a shudder, or otherwise. Theoretically it was at first a matter of indifference whether a-n ended in x or in y; practically, with bodies constructed as are ours, some lines of discharge are innate. Yet connections may be and are made between, *e. g.*, b and x, a and y. Thus names call up not their own "ideas," but their "meanings."

The correlation of tensions is one aspect of a process of which the other is the unification of ideas. This is shown in the acquirement of an art, *e. g.*, writing, cycling. At first are many unneeded and untimely efforts and much confusion as to one's course; with practice the irrelevant acts are suppressed and their force turned into desired channels. In this correlating process, so long as there is a prospect (or feeling) of success, the subject is interested; when failure is inevitable, interest goes. Herein is a clue to the nature or origin of interest; interest is the inner aspect of the muscle-correlation process. Interest attests a nascent adjustment of actions, and roots in the unconscious because at bottom the muscular harmonization is physiological. Interest, however, is never present in first sensations, because it partakes of and follows the intellectual element. First experiences awaken in us emotions, *i. e.*, states corresponding to first or incomplete tensions and tension-adjustments. Emotion lacks clearness because it has no definite or dominant tension to tie it to the objective, and an emotion is difficult to reproduce because it lacks a special muscle element. Given the motor means of recall, and interest appears as an index of the smoothness (or possibility) of interaction of various ideas and their tension-elements. To this extent interest and attention are running-mates.

To the claim that attention can be present only after the idea that evokes it, the objection may be made that a babe is all attention to every intense sensation. But the babe's ideas get their set by these very tensions, and grow in clearness as the tensions pass from mass to particular; unbroken attention is equivalent to catalepsy. The state exemplified in the babe is what I understand Wundt now to assert in his statement, "passive precedes active attention." Further, the stimulus passes to its reaction, the latter sets up an idea in mind; then—with one idea uppermost—comes will (James) or voluntary attention, *i. e.*, knowledge of what has been done, and prevision of a repetition under like circumstances. Yet this idea that is in mind is but a representative of the act to which interest attaches and for the sake of which we wish to attend. By conforming to it, we put ourselves in condition to get a repetition of the former stimulus and its results. How conform? By tensing one

and another muscle until we are aware of the correct mental state. The assertion: The presence of an idea before an act constitutes ac- active (or voluntary) attention, seems negatived when we consider the running-off of a habit-chain in which each step is preceded by its non-willed cue. In fact no sharp line can be drawn between passive and active,—it is a matter of the degree of tensions involved (cf. Münsterberg, 1, I, p. 67); to the actor the distinction is known by a wider grasp of related acts, which calls into play the higher centres, not necessarily to control, yet in action to accompany the habit-centres. We can attend to but one thing at a time, because to us, in our stage of growth, anything short of a unification of tensions produces a greater or less degree of emotion, wherein the harmonization of tensions and mental state are alike deficient, and one knows not what to think. As a matter of fact we can attend to two or more matters that do not interfere in the modes of expression, though here as in any other concatenated act, now one, now another part of what is really one compound act is clear in mind. Yet this differs in no essential respect from any art.

When any part of the body is the object of attention we know we attend to it by experiencing the tension of its muscles, our attention is assured by the strain. When a sense is used as a medium of attention to a stimulus, the strain becomes of minor consideration—necessary to certify the mind is rightly directed, yet of value only as a basis of comparison with the change induced by the awaited stimulus. The difference between active and passive attention, as these terms are commonly used, is that in the former the body-mind complex is in a condition favorable to the recognition of likeness or difference of in-coming stimuli; in the latter comparison is difficult, for either of two reasons: (a) general state of relaxation, (b) great tension of a part not directly concerned in the reception of the unexpected stimulus,—for in either case diffusion is hampered and meaning tarries. Yet comparison may not be difficult in passive attention if so be the stimuli are intense or much unlike, for under these circumstances either the force is sufficient to overbear resistance, or the unlike stimuli find outlet in free channels. The mind feels its freedom when it passes gradually from one object of regard to another, and does not when it goes by leaps, as though a creature of caprice; so we call the gradual progress "active," and feel an inner power, fore-seeing, hence called "voluntary."

Extreme concentration of attention, considered as an inner activity, defeats its aim in that the tension-process becomes greater than that which normally accompanies the awaited stimulus, and thus a disturbance is set up whose outcome is to fill the mind with an irrelevant strain to the exclusion of the one that belongs with the stimulus. Attention (and here tension is meant) needs mostly to be in other parts than those that mediate the stimulus, for thus all interfering action is checked and the parts concerned are free to adjust when aroused. Nor does this apply only to sensory excitations; the most abstract thinking is deranged when the body is out of its normal order. The condition most favorable to the highest state of general attention is the one called "alert indifference." The subject knows his stimulus will be of a certain kind and within given limits. Thus prepared the alert indifference was found to be at its best just as one's inspiration was near its maximum. At this juncture there is a momentary relaxation, which seems to be general. Efforts to attend soon exhausted the subjects. On the view that the muscle tension is an integral part of one's idea, and that maintenance of an idea in mind and maintenance of tension in certain muscles are two aspects of the same fact, it is easy to explain

this tire of attention. The eye fails to "see" clearly because the wonted channels of expression corresponding to certain stimuli are fatigued, although at the same time the eye itself may be in good condition. Like the would-be jumper who takes a long run to get impetus and is exhausted when he gets to the scratch, so one who overstrains his muscles in expectation finds himself unable to seize, or else to react on, the stimulus when it comes. It may be well to repeat there are two distinct facts to be kept in mind of every act of consciousness: the one is a relatively simple chain of three links—end-organ, centre, muscle, and this constitutes a sensation; the other is a complex of many such links, and forms an idea.

Much has been said by the supporters of the central-origin-of-attention theory of the phenomena of attention got by introspection, but an examination of these statements will, I think, show that the condition immediately preceding any particular phenomenon is a muscle state. In other words, the psychic state is indissolubly bound with and dependent on a tension; attention follows, not precedes, that to which we attend.

Helmholtz, to illustrate the freedom of attention, cites the fact we can hold to a faint stimulus whilst a stronger one to the same sense is debarred (pp. 971-2). Evidently it is assumed that stimuli produce reactions proportionate to their objective intensity. That this conclusion is untrue, in so far as our measure of objective intensities goes, is well known. Were the neuro-muscular system always to return to a neutral state after each response, we could expect the stronger stimulus to draw the attention. Further, there seems to be the assumption that a stimulus to, *e. g.*, the eye, is shaped by that sense into an idea. James (I, 50) exposes this error. Hering (pp. 84-5) shows that clearness (the point involved in Helmholtz's claim) depends on the relation of the given sensation to its sensation environments; in other words, that the clearness of a sensation is measured by the relative strength of the interrelations of the particular tension response to the other tension states of the body at the moment. The "stronger stimulus" fails of entrance because opposed by the tension state favorable to its "weaker" rival. Wundt also accords: "The clearness of a *Vorstellung*, whether sensation or memory-image, is conditioned both by the strength of its perception elements and by the sharpness of their apperception" (1, II, 271). Interpreted in the light of the experiments given in this paper, Wundt's words state the equivalent to (a) proper functioning of the end-organ and its immediate responses, and (b) the adjustment of the latter in the general body-state. Wundt admits that an unexpectedly strong stimulus breaks up the preparatory attention-tensions (and this happens at times to such a degree that the new stimulus apperceives the mass that had awaited it); but, apparently, he does not recognize that the over-tension of the muscles concerned in the apperception of the in-coming stimulus also prevents or warps apperception. So far as clearness is concerned, its conditions may be summed up in: If attention checks irrelevant tensions, *i. e.*, if it is expended in such a way as to leave free the muscles needed to receive the awaited stimulus (or idea), it aids; if it checks these constituents, it hampers clearness.

Fixate carefully a small object (and the greater the attention the smaller is the field of application) and it soon disappears. It goes when the feeling of strain is greatest, says Helmholtz (p. 365) and Müller (p. 92). The cause of the disappearance is not that "the strain-idea has driven the object-idea out of mind" (cf. p. 569 for account of rivalry between strain and stimulus), but that the

tensions have diffused into the muscles that serve to give meaning to the acting stimulus. Wundt again: "Impressions qualitatively different require unlike adaptations for their reception. Further, we note that the amount of the feeling of inner expectation keeps pace with the strength of the impression whose apperception we complete. On the exactness of this adaptation depends the sharpness of the apperception. The latter is sharp when the inner attention exactly corresponds to the strength of the impression" (1, II, p. 271). This strength, as we have seen (pp. 548 and 550), is conditioned very largely by the tensions that receive the shock; and we are not obliged to assume any strained condition of a hypothetical inner entity as does Wundt. Our inner expectation really keeps pace with the degree of tensions, and when these lack order their conflict throws the mind into a state of emotion—the inner aspect of the confused muscles. In the experiments herein noted, perception of the time order of (faint) clicks, in § C, was best when there was no feeling of strain whatever; the strain Wundt speaks of is probably only the holding in check of muscles which might inject a disturbing factor into the intended response (cf. with experience of Mr. Luckey, p. 550). If we consider the process of apperception as progressive coördination, we see why consciousness lapses as habit grows,—because attentive consciousness is dependent on shifting tensions; as muscle groups coördinate and function *en bloc*, they escape mutual conflict, and hence give no occasion for opposing states of mind. That reactions do tend to an average status, wherein discrimination or attention lapses, is certain; it is shown by our "constant bias," by Leuba (p. 382-3), who considers it a feature of sense-memory, and again by Daniels (p. 561, n.), who notes the recurrence of certain stock errors. We are debtors to our mistakes if we take them up into consciousness and definitely build them into the way to the correct end, for thus they "lapse," as do all the stages of a series, and so no more offer seductive diversions, but form part of the wall within which our thought runs. Until such assimilation of mistakes is made, the latter are a constant source of error, and may come to be the habitual normal course of reaction. In view of these facts, it seems evident it is these possibles of reaction that determine apperception, and that Wundt's assertion, "Not the intensity and quality of a sensation in itself, but its ability to excite apperception, is the determining factor for the direction of the line of sight," is, as Wundt means it, unfounded. Perception of impressions on peripheral portions of the retina, to use specifically the illustration that for Wundt is general, is either mediated by tensions in part different from those that function with the foveal region, or there is a momentary lapse from the prescribed fixation point. Helmholtz's perception with sides of retina (pp. 934-6) is in point; despite his claim, "attention is quite independent of the position and accommodation of the eyes," there is no need even here to invoke the aid of a hypothetical inner activity. Vision with the sides of the retina enables one now and then, in flashes, to perceive the clear black and white of a disk when it is revolving at a rate sufficient to give a uniform gray. The very point so emphasized by Hering (Hermann's *Handbuch*, III, I, 548) relative to Helmholtz's experiment—that the line of sight must be held with perfect firmness—is the essential condition needed to let the side stimulus work. We cannot speak of eye, but must distinguish eyes and parts of each eye[1]; and to these parts respond different tension-complexes.

The ripening of apperception is a matter much dwelt on by

[1]Cf. C. L. Franklin, *Psychological Review*, II, p. 142, n.

Wundt (1, II, 399 etc.), who claims the mind can divide itself between two or more stimuli, or can perceive them simultaneously. *E. g.*, the stimuli got by the dial-pointer-bell apparatus need not be rivals, but, like two streams, may flow in gradually converging courses until they meet and mingle gently and indissolubly. Nor is the junction for Wundt a result of stimulation, but depends on the ripening of apperception. It matters not if there be no second member; if apperception is expecting such to come, it will act as though the to-be-interpolated stimulus had come, and thus produce "negative errors." Again, though the disparate stimuli have been given, if apperception is unripe, their taking up into consciousness is delayed until apperception is ready to admit them. The obscurity of the process, though great, is not lightened by the explanation of apperception, which "*ausdehnt sich auf die Gesammtanlage des Bewusstseins*" (1, II, 285). It seems fair to infer that by Wundt's view the two series of stimuli in question move in the sub-conscious, and fuse there. But if so, how can active apperception be said to control them? In my own experiments, results like Wundt's were often got, but explicable in a much simpler manner. In the reaction-time experiments, whilst reading, problems were side-tracked into sub- or semi-consciousness, whence their answers appeared in visual terms (cf. p. 565). As Wundt says, "The regular series ran its steady course as though no complication existed, and at a point the simultaneous stimulus joined itself to the former, not as a successive, but as an integral part of a complex idea" (1, II, 399). Yet this does not mean the mind divided itself between the parts, but that separate muscle groups responded to their stimuli, and when in a sufficiently tensed and non-conflicting state, formed the state common to all complicated acts,—and what acts are not in some degree complex? The same process that provides for the preservation of some parts in the complex is sufficient to ensure the forgetting of others.

Daniels' paper, describing work akin to Wundt's complicated reaction-time experiments, and to the study of Angell and Pierce, offers several points for comment. To the subject, while reading aloud, were read series of numbers of three figures each. The subject either ceased reading and at once repeated the number, or continued reading for periods ranging from five to twenty seconds before endeavoring to repeat. It was found the memory after-image does not last fifteen seconds in a reproduceable condition unless its response tension is repeated before its first set is spoiled by succeeding tensions. It is not that the after-image has been in mind,—in that it has a grip in tensions, lies the possibility of its recall. Table III, p. 562 (of Daniels' paper), a general summary, shows the part played in perception and retention by tensions. S., a trained experimenter with self well in hand, made uniform resistance to the impulse to diversion of attention from the reading; but as the stimulus summated its culminating part (the final number of each set) stuck far oftener than either of its predecessors. D., less trained, was unable to resist the onset of the number series, and shows an outgo to the initial number, a return to his reading (*i. e.*, former tension state), and another response to the final number. Here, as before, attention, considered as a conscious state, follows the tension response in every case.

IV.

In the opening paragraph is promised a summary of by-products of the experiments which suggested, and in turn get meaning from, the view of attention just given. The list that follows, considered

from any other standpoint, displays a motley host; but examined for tensions, as characteristics of direction of attention, it presents a homogeneity that warrants recognition. To designate the three sets of experiments, A will be used to indicate the reaction-time, B the association, and C the least interval, group.

In A and in the distraction half of B, the set tasks were more or less hampered by the many and conflicting demands made on the vocal cords. The mere fact that ideas are known in, or by, a nervous system necessitates the presence of some form of expression as an inevitable accompaniment of every stirring of consciousness. By the time any stimulus gets to consciousness, it has found outlet in muscles, and because of our great need for names, a part of this expression is usually in the larynx.[1] Hence use of the voice proved the most distracting device, because of the almost inveterate effort to put our thoughts into verbal form; unless other channels were ready, attention balked. Exceptions that go to illustrate how little depends on conscious direction of attention and how much on diffusion of the stimulus until it finds an accustomed channel, were found. *E. g.*, in A, problems given orally were sidetracked into semi-consciousness, whence they reappeared with visualized answers; in B, thought went on without special names, in a general yet accurate way. Yet in all these cases a general feeling of congruity is our guide, and we do not realize our errors—so frequent—until after they are made; in other words our attention, considered as a mental oversight, follows the tension. Daniels (p. 561, n.) notes an incident common in all similar experiments — the easy formation of habits of response; *e. g.*, any answer once given, whether correct or not, was often repeated. Here it is evident the mind is easily satisfied and directs its attention along the line of habitual tensions. In Daniels' case the vocal cords were in use, and the stimulus given (a group of three numbers) tended to evoke its proper response; as the subject felt himself yielding (*i. e.* as his cords tended to shift one position for another), he resisted not the thought, but the shifting of tensions by putting greater strain on those in use. As forgetting is not doing, so by refusing to name the numbers pronounced, the subject lost the power to recall them; later effort so to do led to discharge in the habit-tracts,—these being uninfluenced by the previous strain. For brevity I have spoken as though all centered in the larynx; while this may not be the case, the point involved is not affected. The fact that in C perception was not hampered by loud reading, save when the latter made one oblivious to sound stimuli, indicates the trouble caused by distraction lies not in the receptive, but in the expressive sphere. Two things cannot be done, nor thought of, at the same time if they need the same or opposing muscles for their execution; if, however, different muscle groups are exercised, many acts can be simultaneous. As so stated this is self-evident, yet many experiments have been made to prove it (cf. Paulhan); further may be noted: in A partial products fused of themselves; in B associations presented themselves (cf. Wundt, 1, II, 398-9); in C the click or shock gave its own order. In none of these cases, as a rule, were the results got by any "direction of attention;" they came in spite of distraction, were mediated by tensions other than those in use for the distraction. If the term "conscious" be restricted to those processes of which we are immediately aware, then the results just noted, of thoughts that appear full-grown, may be said to come from the unconscious. Ac-

[1] In accordance with the laws of simplicity and economy of effort, the flexibility of some parts of the vocal apparatus far exceeds the rate of any other voluntary act.

cept this limitation and our experiments throughout show that fatigue lets the unconscious work, *i. e.*, it lessens distraction, permits a freer distribution of attention. If fresh we had more force available than laboratory experiments required and the inevitable overflow came to light in spurty tensions and frequent responses to irrelevant matters. Too great strain entailed a cramp that prevented some of the most customary associations in B, but these were made so soon as the strain eased (cf. Lalande and Paulhan). In the "unconscious" work noted above, a certain order seemed imperative. Factors in A had to be put in a habitual way; in C the bias, or constant error, defied our efforts at conscious control.

The usual muscular tensions that characterize or accompany concentration of attention, were well marked in all the experiments. Checked breathing, suspension of movements, a strain about eyes or ears, were common. In C the effort to hold an even hand between stimuli to organs of the same sense brought out clearly the great dependence of "balanced attention" on equilateral tensions. To be alert and yet neutral, *i. e.*, to be intentionally indifferent, it was necessary to fixate a point in the median plane and to have an equal distribution of tensions on each side of the body. The slightest deviation therefrom, if but a tendency to a side-movement of the eyes, was sufficient to make uncertain the judgment of the order in which the clicks came. As concentration is tension, it easily passes by overplus into distraction, or opposing tensions. In A uncalled fingers, and even the whole arm, made irrelevant reactions; in B the very effort for great attention defeated its aim; in C the order was easily lost when too much awaited. But attention is not only a matter of tension on its physical side. Without change concentration soon degenerated into stupor; all distractions soon dulled; in each case aid was got, both for concentration and for distraction, by shifting positions. The readjustment of tensions was conducive to distraction if the stimuli were received whilst the change was in progress, because the correct response was but one of many possible tensions; if the stimuli came when the tension-adjustment was just below its crest, they found favorable reception. To get the faint clicks in C, concentration (*i. e.*, suspension of motion) had to be very great; my custom was to draw a full breath and begin to expire just as the clicks were expected. The momentary balancing on the tension-crest enabled the clicks to come as if into the field of vision.

So inveterate (or normal) is the habit of association that it is practically impossible to get trace of an idea without giving it a space setting. Definite localization was all but general; those few cases wherein it failed may probably be explained as unscrutinized. In A the stimuli, coming from the operator, seemed to be external in nature; they and their responses were free from subjective control. In B and C the associations and sensations were projected, and their spatial distance was usually strongly felt. In B at times the consciousness of place was greater than that of the object felt to be there. In C if the focus, fixated in order to keep attention median, was distant, the stimuli were remote; if near by, the stimuli came near. The evident reason for these facts is that an idea rests on a complex, each element of which has its harmonious space-reaction. The nature of a complex idea (an object of thought composed of known elements) necessitates a play of tensions to give its full expression, and full presence as well. Put into terms of an inner activity this kaleidoscopic play may be formulated in: Ranging is necessary for fruitful attention, *i. e.*, in order to get many associates. Mere attention, considered as fixation, lands the mind in

blankness. The fact noted above, that some distraction is an aid to work, finds an inner correlate in the need of "ground-wires" to draw off the excess of energy. The non-attended incidents and possible stimuli about us (for concrete, though extreme, stock-cases, take the button of Scott's class-mate, Schiller's rotten apples, the uproar of the mill) are the background on which we project and estimate our heeded experiences.

Spatial readjustment of our mental stock was often a very conscious and troublesome process. Thus, in A difficult problems were analyzed and solved piece-meal on the lines of least resistance; in B perplexing key-words were dismembered and referred to their root-origins; in C the sensations were commonly translated into objective figures. In B it was necessary to arrange the associations in groups in order to retain them; in C the time order had to be decided by an immediate impulse, else would consideration drive out the possibility of decision. Our experience in C indicates that judgment of time order depends on one's interpretation of his space-experiences. Space to us is largely a matter of projection, and with normal persons this is in terms of sight (cf. Wundt, I, II, 121-2). So long as the subject in C was fresh and passive, the time order of the stimuli was well perceived; certainty was greatest when there was least conscious effort to decide. Quite otherwise was the matter when for any reason, fatigue or wandering mind and shifting tensions, the order was obscure. In the latter cases decisions, as noted above, wavered between feeling and judgment, *i. e.*, between the impulsive and the conscious. Yet when these opposing claims were examined, I could not see there was anything else to motive them than differences of perceived intensity. My impression is that in the immediate, sensory form the body-state was in a condition of alert indifference; that in the "feeling" form the body-state was one of change, but that the stimulus-tension got and retained a relatively stable condition which, in time, often sufficed to gain it notice. In the last named form one wonders if he started from the stimulus and went to the related ideas, or from these latter over to the idea about the stimulus. But as has been said, when the immediacy of the struggle, the basal feeling of the sensation, was gone, the case was rejected. It should be remembered, however, that these uncertain cases were but a fraction of the series; often subjects gave correctly the order of nearly entire sets (twenty trials each), and were sure of their answers. The doubtful cases bring out the fact that the stimuli were known as unequal; of this, more later.

A constant error, rather a general bias, has been noted in the experiments of the third part. It was easier to decide for one side than for the other, as was shown by the preponderance of correct answers on the favored side, due, probably, not to better perception, but to an excess of answers in one direction. This is akin to habit, perception of the probable, apperception ruts, and, I believe, is related to certain fixed muscle adjustments. For S. and D. this constant error has been shown in Table 4, and in 13 is shown the result of shifting body conditions with intent to redistribute tensions. Although various subjects knew of this failing and endeavored to guard against it, the undertow was too strong to be resisted. At times the bias was maintained, although the intensities of the stimuli were made to differ considerably; now and then the error would change from one side to the other, but in the long run it was fairly constant. Because of this bias, experimentation with some subjects was given up.

Here may be noted the observation that organs of the same sense

receive like stimuli in unlike ways. Differences in the abilities of the eyes and of the ears are well known; analogous is the case of the hands. For a time it was possible to judge the order of shocks in C by these qualitative differences in sensation. There was needed a certain degree of intensity in order to arouse these sensation-forms; below the minimal quantity quality failed to appear. In the case of the very faint clicks this loss of quality was very great. At the outset and for some time thereafter, these were projected on a level with and a trifle back of the shoulders; they were seen, with the eye of imagination, as whitish spots on black backgrounds, like the pictures that represent stars in constellations in astronomical text-books. As intensity increased the clicks became more like experiences known as sound, and so came up toward and into the ears. Yet, unless the subject was in good responsive condition, at the short interval (.024σ), with increased intensity the clicks would overlap, either in a confused sound, or as overlapping auroral flashes, in terms of sight, and before the face. When the clicks were really simultaneous, they were perceived as one located in the occipital part of the brain. In every case as intensity grew, the clicks approached each other; due, probably, to the fact that the tension responses were greater, and so intermixed. Bolton (p. 228) notes, "The strongest sound seemed longer than the rest;" because its effect, more widely diffused, aroused the idea of extension.

It was our custom in C to interchange the battery connections, whereby the stimulus that had gone to one side should be sent an equal number of times to the opposite side; by so doing we sought to neutralize any lurking inequalities. But one day, while using shocks with indifferent attention, we crossed our arms and thus received the right hand shock in the left hand, the shock from the left side in the right hand (cf. p. 550). To our surprise the stimulus in one hand would at times entirely disappear, and when felt was much weaker than its mate. That the objective intensities were unchanged we proved by tests; that the trouble was not a local defect was shown by the fact that at times a plain after-sensation of the shock could be felt in the fingers, though the original sensation had escaped detection. On some days the loss of the shock was especially common in one hand; at other times the opposite hand so suffered; while on yet other days the loss shifted back and forth. Knowing that both shocks were given and of like intensity, one could not avoid watching for a sensation on the perplexing side; but expectant attention in this case was not equal to sensation, although often it was impossible to decide whether a faint trace of the missing sensation had been felt or imagined. These cases seem to be veritable cramps of attention. In one series, designed to get twenty judgments, after nine had been given, I had twenty-one trials on the tenth before making a (guess) judgment. Here shifting one's position did not aid perception. After the eighth trial I walked about to shake off the cramp; after the tenth trial the left cup (by which no sensation had been aroused) was tested and its stimulus found to be working normally. In this case the trouble, though present in a few early cases, did not become set until the series was half done. Another day the cramp began at the outset, and forty trials were made before a judgment could be given; in the final trial the stimuli were plainly felt in both hands, and in their order; in every trial the stimuli had been sent and in changing order. Thirty of the trials were made with right hand above, the remainder with left above. In the thirty-second trial the right-hand shock was missing; in the others of this set the trouble was

with the left side. Not that the left stimulus was always entirely absent. In this particular set my notes show six times when the left *seemed* to lead, although the only stimulus "known" was felt on right; each of the six was a case of left first. When the bias to one side (and especially to the right) was strong, the shocks on the left became dissociated from the fingers, and commonly settled in or near the median plane, at the crossing point of the arms.[1] Two naïve subjects who were used to test this matter, found the median plane tangle; but, introspecting less, and less anxious for exactest judgments, they did not stick on the dead centre, but guessed themselves out of the difficulty. That the trouble was not in the apparatus was certain. The stimuli were given by the break, which gave a stronger shock than the make. In a troublesome run, in which one side repeatedly failed to take part, a slight delay in removing the hands from the cups enabled me to feel the make. So unexpected was this that, despite its real faintness, it startled me far more than had the regular stimulus.

If the non-appearance of the stimulus noted above be due to an attention-cramp, it may be asked to which side attention was given. As a rule it is next to impossible for one designedly so to control his attention as to become oblivious to surrounding stimuli; the very effort to turn away from a stimulus often puts its claim more forcibly. So, too, it was practically impossible for one to fail to perceive an awaited stimulus without becoming disposed to be alert for its coming; yet the positive and strenuous direction of attention actually did less to facilitate perception than did a state of indifference. In general the shocks in the side to which attention was given were felt as being much weaker than those in the unattended side,—doubtless because the strain diffused until it cramped the mobile parts needed to receive the expected shock. This fore-tension explains in part why "not even shock affects the muscular form of reaction," for not only is the shock's work begun, but once begun, the probability of diversion is lessened. In a sense it may be said, "Expectant attention and sensation [are] identical processes." (James, I, p. 429). In the case noted above the tension in the attended hand was as great as, or greater than, that produced by the shock, hence the latter was felt little or not at all. In the other hand the contrast between the relaxed and the contracted conditions gave a good example of passive attention, with a difference of states so great as to compel regard. Hence in this experiment serial order was often upset, because at times the only shock-tension experienced was in the non-attended hand, and this was heeded because the only other mental rival was the consciousness of a cramp. In truth the latter was no rival. Treating the hands as disparate senses, the case was akin to our common experiences wherein we refuse response to so-called distractions. Again it may be said a certain amount of distraction facilitates perception, in that it prevents this overflow of tensions (compare Urbantschitsch and Münsterberg, 4). "Distractions" need to be further differentiated, since they may be more attractive and absorbing than one's set task, and so fill his mind; or they may be suggestive of varied associates and so make concentration all but impossible.

It may be objected that the illustrations given of cramped attention are all exclusively physiological, and the extension of inferences therefrom to ideas questioned. But quite similar were the experiences in B—association. While adding for distraction, it was

[1] Compare "An Experimental Study of Simultaneous Stimulations of the Sense of Touch," W. O. Krohn, *Journal of Nervous and Mental Diseases*, March, 1893.

much easier to have "knowledge-about," *i. e.*, to broadly survey, one's addition, general feeling, flight of time, progress of the experiment, and the like, than it was to attend to the key-words. The effort to hold fast the word bred stupor, gave cramp; the tensions corresponding to the work of addition, one's acts, etc., were in continual change. Whole sections of common thought were often left untouched during the time allotted for association.

In any discussion of Attention we need to consider first the name, for it is a word that includes in its various meanings all mind action—passive and active,—and because of this range its explanatory value is but a pretence. Leaving aside the fact that consciousness is active *per se*, the attention that we know is a resultant of tensions, *i. e.*, an element in knowing and so is present in all states of mind. What the motive power back of this tension is, we do not know; but nothing is gained by giving it a name of ignorance and then subdividing this X into active and passive forms. We feel mind action to be passive when aroused chiefly by sensory means (and these include a large part of the suggestions that motive idle revery); active when aroused by ideo-motor means. In the former we find ourselves in an attentive state because of the impulsive response of sense-organ adjustments; these in cases, *e. g.*, iris and lens, go on out of mind. In the latter the kinæsthetic idea is necessarily in mind before its sequent steps are aroused, and the mind, prevising, feels its initiative. In either case attention as a psychic state follows and depends on tensions.

The study noted in these pages was carried on under the general direction and with the constant aid and counsel of Dr. E. C. Sanford, to whom my thanks are due in large measure; however, he is no way responsible for the short-comings. To President G. Stanley Hall for stimulating suggestions and insights that rouse one to new views, and to Dr. W. H. Burnham for sympathetic criticism and assistance all along the way,—I wish especially to acknowledge my obligation. Nor would I omit to recognize my debt to Mr. Jonas G. Clark, to whose generosity is due the facilities so abundantly furnished for my work. It is a privilege to thus express my indebtedness to these men, for, because of them, the work was made a pleasure.

V.

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NOTE.

While Mr. Drew's experiments on Association were in progress, I undertook a similar series in order to check his results by those of a second observer. The method used was not quite the same, the most important difference being a greater freedom of association on my part, *i. e.*, each association was not held strictly to the original stimulus word. The nature of the data gathered in such experiments makes it almost indispensable that each observer should work up his own results, and this I have not found time to do, with sufficient completeness for exact tabular presentation. I venture, however, to give here such general statements as a rather full preliminary examination seems to justify.

In the first place my lists, like those of Drew, show little difference in the fertility of association between those series in which addition was performed and those in which attention was left free. This unexpected result may depend, as he suggests, on an unintended distraction, introduced by the knowledge that the time for getting associations was limited, or on the fact that in most cases there was not thorough absorption in the adding, the associations being secured at intervals of slight neglect of the means of distraction. Another effect of the adding is apparent in my case, however, in the greater number of cases in which wholly extraneous ideas entered, or in which an association once glimpsed was lost in whole or in part before the time came for recording. The subjective feeling of greater irksomeness also distinguished the tests accompanied by addition, and introspection seemed more difficult.

The most marked qualitative difference between the series with adding and those without is a clear preponderance in the latter case of associated phrases (quotations and the like). A similar relation, though quantitatively much less, appears in Drew's table F, where the percentage of "word" associations is greater in the series with full attention. This difference may be caused by the need of at least a partial functioning of the language apparatus, central and peripheral, in the adding (cf. the article of Theodate Smith above).

As with Drew and other experimenters by this method, a considerable number of associations noted in the first trial with each series recurred again in the second trial, but the distribution of repetitions among the series is different in my case from Drew's, the series in which adding was used in both trials standing out alone with a decidedly higher proportion of repetitions than the rest.

Of Drew's observations during the course of the experiment, several were very frequently confirmed in my series, most strikingly of all the tendency to internal speech and to the immediate spatial location of the associations started. The very first thing that could be observed in most cases, after the method of work had become familiar and the operator practiced in introspection, was a mental pronunciation of the stimulus word, and a verbal accompaniment was also found with many of the succeeding associations. The tendency to locate followed immediately upon the recognition of the stimulus word, or possibly as a part of its recognition. At times it served as a sort of algebraic symbol, and took the place of a more tardy but fuller image in visual or other terms. It was often a kind of mental pointing, an unformed "that thing, there." No classification according to period of life was attempted in my case.

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PSYCHOLOGICAL LITERATURE.

The Theory of Knowledge. A Contribution to some Problems of Logic and Metaphysics. By L. T. HOBHOUSE. London, 1896, pp. 627.

According to the author, the world of thought at the present day is in a somewhat anomalous amorphic condition. The warehouses of science are being filled to repletion with an accumulated mass of facts, the details of which even a Heaven-born Aristotle could not properly grasp and unify. The deluge of specialism still continues. Systems of philosophy that antedate this deluge are therefore undermined by it; a new construction is necessary. The philosopher, like the theologian, has not the hardihood of the past; he proclaims with more diffidence than formerly his God-given panacea of all difficulties. Moreover, there is an elegant skepticism abroad. The question is not only, Is philosophy skeptical in its tendency? but also, Is not science bankrupt? It is the elegant, aristocratic thing to do, to languidly lean back in your carriage as it rolls along Rotten Row, and to declare that that is immutable and sure which—suits your needs. The author endeavors, in a fair-minded way, to present to us the result of some "psychical chemistry"—he will unite the merits of Mill and Spencer with those of Lotze and Hegel, and present a higher whole.

The work is too large to allow of an analysis of it here, but a few points may be noted. Logic, in contradistinction to psychology, we are informed, examines the content, grounds, and validity of belief in general. In logic we have to deal with knowledge, that is, the relation of belief to fact. It may be asked, are not our beliefs facts? and if our beliefs are not facts, how are we to find out the difference—by other beliefs? This is decidedly a topic for psychology preëminently. Knowledge of the immediately present may be called apprehension and this the starting point of knowledge. The content of immediate apprehension is extension, size, shape, position and time. The atomic sensation is a figment. Memory "is not a mere image or fainter repetition of something which is *de facto* past." Such an image could be only—an image, a present fact, "which vanishes in its turn and requires memory to recall it from the limbo of departed thoughts." "Memory, then, is an assertion—or, if you prefer to employ the word as a name for a permanent capacity of the mind unknown to us except by its results—it is a faculty of making assertions." "It is an assertion of the past, and hence a reference to something not now present," which appears to amount to this, that the past or the knowledge that an event is past is an assertion of the past, a statement perilously similar to the so-called Law of Identity. "Judgment affirms the reference to reality contained in an idea," and "in so doing it necessarily predicates something of something otherwise known." "Negation rejects a suggested reference." The author further treats at length of inference and knowledge, enlarging on the doctrines of the conception of external reality, substance, etc.

The author is, on the whole, somewhat diffuse, often quite diffuse, but is very fair-minded, an accurate psychologist, and has furnished an admirable exposition for students as well as a suggestive treatise for others.

ARTHUR ALLIN.

Psychology and Psychic Culture. By REUBEN POST HALLECK. American Book Co., New York, 1895.

Mr. Halleck's psychology, which comprises some 360 pages, is designed as a text-book for high school pupils, and to quote from the author, "aims to present the latest ascertained facts of physiological as well as of introspective psychology."

The book is dated 1895, but none of the more recent contributions of French and German psychologists are mentioned, nor does the author manifest any acquaintance with much of the psychological literature available in English. A pupil might read the book carefully from beginning to end without so much as a suspicion that such things as psychological laboratories existed. On p. 65 Weber's law is thus stated: "To produce a change in any sensation, the stimulus must be increased one-third."

The book retains the old faulty classification of mental phenomena with some justification, since the text-book is an elementary one designed for pupils under twenty years old, but to give no hint that any other method of treating the subject exists, is scarcely in accordance with the author's claims. In the chapter on the emotions, the only authority to which the author refers for expression of the emotions is Darwin's "Expression of Emotions in Man and Animals" (1873). The book is really of the age of Porter, with a very thin and spotty varnish of more recent information.

The best portion is that which is devoted to practical precepts for emotional and voluntary control. Here the author has evidently read Prof. James' chapter on "Habit" to some purpose and uses illustrations well adapted to the design of the book.

THEODATE L. SMITH.

L'Année Psychologique. Par H. BEAUNIS et A. BINET, avec collaboration. Deuxième Année, 1895. Paris, Felix Alcan, 1896.

Psychologists are again heavily indebted to the perseverance and industry of MM. Beaunis and Binet and their collaborators. This number of *L'Année*, as the last, falls into three parts, devoted respectively to original articles, to general reviews of literature in several important fields, and to summaries and reviews of the publications of the year. The first two and last form almost equal parts of the entire work,—about 500 pages each.

The volume begins with an article by Prof. Ribot (Paris), "*Les Caractères anormaux et morbides.*" Under this title are treated those unstable types of character which range in intensity from the change accompanying religious conversion, or the two phases which the same individual shows in his place of business and his family circle, to the morbid forms of double personality. All these types are reduced to one, whose differentia is a lack of proper subordination of the different tendencies in the character; and the term *infantalisme psychologique* (psychological childishness) is proposed to cover the entire class.

Prof. Forel[1] (Zürich) contributes "*Un aperçu de psychologie comperée.*" The article is based upon a discussion of the nature of consciousness in its relation to the social habits of ants. The social actions are reduced to automatic movements, mainly the function of ganglia in the head,—which persist in the race by survival. The development of consciousness in general is stated to consist in the subordination of the various independent groups of automatic actions to some one central group. The treatise is made the basis

[1] Page 18.

for long disquisitions upon the nature of consciousness and the rival theories of heredity. The article contains much suggestive matter, though it is not always easy to see how some of the subjects treated are related to the main theme.

Prof. Flournoy [1] (Geneva) gives the results of an interesting investigation into the times of reading and omitting words. Two lists of twenty-four words each are prepared, in each of which twelve words come under some general category. In the first list the subject is required to read all the words which come under the category, in the second to omit them. It is found to require 25% more time to omit than to read a word. The writer's experiment does not seem quite "pure," however, since it assumes that the times of reading and omitting the words which do not belong to the category remain constant. The fact is taken to prove that the negative judgment is not so immediate as the positive; and this is explained in terms of a predisposition of the cortex to pronounce the words which come under the general category expected.

The results of some experiments upon association are presented by M. Bourdon.[2] The contribution is mainly valuable as an attempt at a method of classifying the results of introspection. It affords in this way much material as to the nature of the mental processes which underlie reading and the formation of successive associations in general.

Prof. Van Biervliet[3] (Ghent) continues the investigation, begun by Flournoy, Dresslar, and Seashore, of the illusion of weights of various sizes; and obtains practically the same results as those authors. The results are stated in the formula that apparent weight varies directly with actual weight, and inversely with volume. Flournoy's disproof of the innervation sensation is challenged, — it seems, on insufficient grounds,—by the statement that volume acts through vision or the cutaneous sensibility upon the innervation sense.

"*Circulation Capillaire de la Main*," [4] by MM. Binet and Courtier (Paris), gives an accurate study of the effects of respiration, of the position of the arm, of cold, of noises, and of mental work upon the pulse. The paper is remarkable for the ingenuity with which many sources of error have been discovered and eliminated. The most important result of the experiments was to show that many constant individual peculiarities exist, and persist over long periods of experimentation. The investigation is to be extended to the effects of the emotions, and the results are promised for the near future.

The same authors give an account of a method for applying the graphic method to study the action of the fingers in playing the piano.[5] A Marey tambour is connected with the keys of a piano in such a way as to record the intensity, duration and form of the pressure exerted in striking them. This affords an excellent means of studying the finer shades of expression in music, and of discovering the errors which are made in rendering a selection.

M. Paul Xilliez[6] finds that a list of figures tends in memory to become continuous,—that is, that the arithmetical differences between the succeeding numbers in the series tend to decrease.

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[1] *Note sur le "Temps de Lecture et d'Omission,"* p. 45.
[2] "*Recherches sur les Phénomènes Intellectuels.*"
[3] "*La Mesure des Illusions des Poids,*" p. 79.
[4] Page 87.
[5] "*Recherches Graphiques sur la Musique,*" p. 201.
[6] "*La Continuité dans la Mémoire immédiate des Chiffres et des Nombres en Série Auditive,*" p. 193.

In "*Le Peur chez les Enfants*,"[1] Prof. Binet gives the results of a *questionnaire* on morbid fear in children, addressed to French teachers. The results show the great prevalence of such morbid emotions as fear of the dark, of solitude, and of loud noises. It is found to be coincident with poor physical development, ill health, and with a vivid imagination, and to be more frequent in girls than in boys. The article ends with some practical directions for overcoming the psychosis.

To M. Victor Henri has been intrusted the work of the volume upon cutaneous sensibility. He contributes an original article, "*Recherches sur la Localisation des Sensations Tactiles*,"[2] which embodies the result of his recent work in the Leipzig laboratory and the "*Révue générale sur le Sens de Lieu de la Peau*."[3] In the former article M. Henri insists upon the advantages of localizing a touch upon the skin on a photograph or model of the member, instead of upon the member itself, and upon the value of introspection during the experiments. His results are practically coincident with those of his previous contribution to the subject. In the explanations of the results, much attention is paid to the influence of the visual image, but the author does not seem to be familiar with Miss Washburn's treatise on the subject. He promises, however, to give a complete theory in a later article. The general review of the literature is admirable in the main, though here again, perhaps, a slight tendency is shown to underestimate work which is not done by the author's own method.

MM. Binet and Henri collaborate in a review of the work done upon what has now come to be termed, technically, Individual Psychology.[4] They suggest a new series of simple tests to supersede those now in use, which were proposed by Jastrow, Cattell, Kraepelin, and Münsterberg. The tests are intended to cover ten processes: memory, the nature of the memory image, imagination, the faculty of comprehending, suggestibility, æsthetic and moral sentiments, the force of muscle and will, and motor adaptability.

Many ingenious tests are given under these heads, which are selected from those departments in which individual variations are greatest. The entire series can be applied in an hour and a half, and requires no elaborate apparatus. It is only to be regretted that the authors should find it necessary to sacrifice scientific accuracy of statement to popular exposition. The faculty of comprehension and force of will belong to the psychology of Wolff rather than to the psychology of the laboratory.

In addition to these reviews, Dr. Azoulay covers the recent literature in the field of histological psychology, M. Jacques Passy gives a thorough and comprehensive résumé of the important literature on the olfactory sense, and M. Henri gives one of the clearest and most comprehensive statements of the use of the theory of probabilities in psychology that has as yet appeared.

The reviews and abstracts of current literature occupy the third part of the work. This is, for the most part, a model of what such work should be. The abstracts themselves are in the main very thorough, and always extremely clear. The arrangement is excellent, and the work will undoubtedly prove of great value to the psychologist. It is difficult to see how the work, as a whole, could have been improved.

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[1] Page 223.
[2] Page 168.
[3] Page 295.
[4] "*La Psychologie Individuelle*," p. 411.

The bibliography and index are translated from those prepared by Messrs. Farrand and Warren for the *Psychological Review*.

One closes the book with a feeling of wonder that the editors—M. Binet in particular, upon whom the greater part of the work seems to have fallen—found time or energy to do so much, and to do it so thoroughly. W. B. PILLSBURY.

Pour et contre l'Enseignement philosophique. Extrait de la Revue Bleue. Paris, Alcan, 1894, pp. 178.

The articles and replies which compose this volume appeared in the *Revue Bleue*, between January and May, 1894. The articles were written by the journalist, M. Fernand Vandérem, on "*l'Enseignement de la Philosophie: Une classe à supprimer*" in the above *Review;* the letters form replies to and discussions on these articles contributed by the leading educators of France, amongst whom are MM. Th. Ribot, Boutroux, Paul Janet, Fouillée, Marion, Marillier, l'abbé Clamadieu and H. Taine.

The volume contains no statistics, little or no precise data, and the proposed reforms are only hinted at; it is largely a popular discussion on the present status of philosophical instruction in the lycées of France. M. Vandérem says he wrote the articles in question "from intuition, memory and *sentiment* mostly, without documents, with a complete ignorance of the analogous controversies which had preceded." He writes with grace and ease, and with the delightful *insouciance* characteristic of a French journalist.

His fundamental criticisms, directed not against philosophy in general, nor against the university, but against the present method, quality and quantity of instruction in philosophy, are on the whole supported by the other writers. Summed up, his charges may be stated thus: The course of studies in philosophy is too full, too over-burdened; the professors have not the time to compass it; the instruction preparatory to philosophical instruction is unsuitable; the scholars are hence not prepared to comprehend it; the professors are above their task in matter of knowledge, and "are not able or do not deign to lower themselves to it;" the rôle of instruction in philosophy is to teach the pupils not systems, but to think,—to form not erudite metaphysicians, but reflective and moral minds; in this sense the courses of study ought to be corrected, and in this sense the professors ought to teach.

M. Th. Ribot writes: "I would say (and I could cite high authorities, too, if need be) that too often the instruction is above the heads of the pupils; moreover the greater part are dissatisfied with it, and the others become intoxicated with generalities and formulæ, under which they are unable to subsume anything, because for that years would be necessary. The defect lies in the course of studies, but more especially in the methods." This cry is again voiced by M. Boutroux: Instruction in philosophy is an initiation into philosophical reflection, it is not a hasty exhibition of all philosophy and of all the history of philosophy in a short space. M. G. Monod objects energetically to present state of affairs and to the "*scribendi cacœthes philosophique*" engendered by the present system of teaching. M. Fouillée wishes to extend the course in morals, and especially social ethics. M. l'abbé Clamadieu wishes to simplify the matter and to introduce philosophical instruction into all the classes without prejudice to a class in "*philosophie finale.*" M. Vandérem concludes that all those who are the reputed leaders of thought in France have pronounced in favor of a remodeling of the course of study and of a betterment in philosophical instruction.

ARTHUR ALLIN.

NOTES AND NEWS.

Mr. C. H. Judd, a graduate of Leipzig University, has been appointed instructor in Psychology at Wesleyan University. Mr. Judd is at present engaged upon a translation of Wundt's recently issued *Grundriss*, under the direction and with the coöperation of the author. The book will be published by Engelmann of Leipzig.

Mr. H. C. Warren — whose appointment at Princeton University should have been given in the previous number of the JOURNAL as that of assistant professor—has become associate editor of the *American Naturalist*, with charge of the department of Psychology.

Professor Titchener has undertaken the translation of Wundt's *Physiological Psychology*, 4th ed. The translation will be published by Swan, Sonnenschein (London) and Macmillan (New York). It is hoped that the first volume will appear in September, 1897.

Mr. E. L. Hinman, a Ph. D. of Cornell University, has been appointed instructor in Philosophy and Psychology in the University of Nebraska.

Miss Alice J. Hamlin, Ph. D. (Cornell), has been selected to teach Psychology in Mount Holyoke Seminary.

The preliminary announcement of the *Dictionary of Philosophy and Psychology*, to be published by Macmillan & Co., under the editorial supervision of Professor Baldwin of Princeton, in 1897, mentions the following as the general features of the work: "It will contain concise definitions of all the terms in use in the whole range of philosophical study (philosophy, metaphysics, psychology, ethics, logic, etc.). It will contain such historical matter, under each term, as may be necessary to justify the definition given and to show that the usage suggested is the outcome of the progress of philosophy, together with special historical articles. It will have very full bibliographies, both of philosophy generally and of the special topics which are connected with it." Psychology will be cared for by Professor J. McK. Cattell, Mr. G. F. Stout, Mr. W. E. Johnson, Professor E. B. Titchener and the editor (normal psychology), Professor Jastrow (mental pathology and anthropology), and Professor Lloyd Morgan (biology).

BOOKS RECEIVED.

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DYDE (translator). Hegel's Philosophy of Right. Pp. 365. London, George Bell & Sons, 1896; N. Y., Macmillan & Co. Price, $1.90.

LE DANTEC. Théorie Nouvelle de la Vie. (Bibliothèque Scientifique Internationale, Vol. LXXXIII.) F. Alcan, Paris, 1896. Pp. 323. Price, 6 f.

ERDMANN. Outlines of Logic and Mataphysics. Translated from the 4th (revised) edition, with prefatory essay by B. C. Burt, Ph. D. (Introductory Science Text-books.) Pp. xviii+253. Swan, Sonnenschein & Co., London; Macmillan & Co., New York. Price, $1.60.

FOUILLÉE. Le Mouvement Idéaliste et la Réaction contre la Science positive. Pp. 351. Félix Alcan, Paris, 1896. Price, 7.50 f.

GIDDINGS. The Principles of Sociology. An analysis of the phenomena of association and of social organization. Columbia University Press. Macmillan & Co., N. Y. 1896. Pp. 476. Price, $3.

LÉVY. Psychologie du Caractère, Contribution a l'Éthologie. Pp. 207. F. Alcan, Paris, 1896. Price, 5 f.

LUQUEER. Hegel as Educator. Pp. 185. (Columbia University contributions to philosophy, psychology and education, Vol. II, No. 1.) N. Y., Macmillan & Co., May, 1896. Price, $1.

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Proceedings of the American Medico-Psychological Association at the Fifty-first Annual Meeting held in Denver, June 11-13, 1895. Published by the Association, 1896. Pp. 258.

RIBOT. La Psychologie des Sentiments. (Bibliothèque de Philosophie contemporaine.) F. Alcan, Paris, 1896. Pp. 443. Price, 7.50 f.

SPIR. Pensée et Réalité. Essai d'une réforme de la philosophie critique. Traduit de l'allemand par M. Penjon. Pp. 566. F. Alcan, Paris, 1896. Price, 10 f.

STOUT. Analytic Psychology. 2 vols. Pp. 289-314. (Library of Philosophy. Edited by J. H. Muirhead, M. A.) London, Swan, Sonnenschein & Co., Ltd.; New York, Macmillan & Co., 1896. Price, $5.50.

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